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Woods Hole Oceanographic Institution

Arctic Remote Autonomous Measurement Platform Post CEAREX Engineering Report

by

K.R. Peal

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November, 1990

Funding was provided by the Office of Naval Research under Contract No. N00014-86-C-0126.

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Arctic Remote Autonomous Measurement Platform Post CEAREX Engineering Report

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Technical Report

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Approved for Distribution:

Albert J. Williams 3rd

Albert J. Williams 3rd, Chairman
Department of Applied Ocean Physics
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1. Summary

The Arctic Remote Autonomous Measurement Platform (ARAMP) is a buoy design by engineers at the Woods Hole Oceanographic Institution to meet the need for a flexible, general-purpose self-recording instrument for use in the high Arctic (reference 1). It takes the form of cylindrical housing which is deployed vertically in the surface of pack ice. Its sensor complement consists of sensors inside the housing and on a tower above as well as instruments in the ocean below. The cylindrical housing also contains control and sensor signal conditioning electronics and an optical disk recorder which is used for mass storage. In addition, data telemetry is provided by a platform transmitter terminal to the ARGOS satellite system and a custom two-way VHF radio system for offloading larger quantities of data over line-of-sight distances.

The development chronology of these systems is as follows:

- one prototype system tested during Prudhoe Bay operations in 1987;
- five redesigned buoys were prepared for the Coordinated Eastern Arctic Experiment (CEAREX, reference 2) in 1989;
- engineering development and testing was performed on the five units during 1989/90 to resolve the problems encountered during CEAREX.

This emphasis in this report is on the engineering which was performed on the ARAMP's after CEAREX for two purposes:

1. to solve problems encountered during CEAREX;
2. to evaluate all aspects of the buoy's performance and make changes as necessary to achieve an operational system.

The biggest known problem was that the optical disks did not operate reliably. The other problems were a host of minor hardware and software details which prevented the expected acquisition sequence from occurring as desired.

The work consisted of a sequence of test, evaluate, redesign and retest until successful operation was achieved. Initially the tests were designed to answer the question "does it run and record data?" As fewer problems remained, the tests progressed to simulate more and more realistic conditions and the data recorded during the test was evaluated to answer the question "does it record useful information?" The final step in this procedure was a planned field deployment which was cancelled due to lack of funds.

The status of the systems is that all five now operate and record useful data. Two of the systems have been modified to ensure good optical disk operation at temperatures to -40C.

2. Description of ARAMP

The Arctic Remote Autonomous Platform (ARAMP) was designed specifically for deployment in pack ice to make environmental measurements unattended for extended periods. The sensor complement includes:

- a hydrophone and instruments in the upper ocean which are connected via an electromechanical cable for support, power, and communication;
- internal sensors to measure ice movement and engineering parameters;
- meteorological sensors on a tower above the instrument.

Table 1 gives detailed specifications for each sensor and subsystem. Figure 1 shows the complete system as deployed during CEAREX.

The instrument is self contained, powered from batteries contained in the pressure case and includes a high capacity mass store device for recording data. It provides several types of radio telemetry to allow its performance to be monitored and recorded data evaluated during deployment.

The system architecture is based on a low power version of the IBM-PC. This provides access to many software packages for program development and allows testing of hardware and programs on readily available PC's. The instrument runs a slightly modified form of MSDOS and the acquisition software uses standard programming languages (primarily C). Figure 2 is a block diagram of the system showing how the various elements are interconnected.

A more complete description of the system and its operation is presented in reference 4. Also of interest is the system's use of a write-once-read-many optical disk recorder. Testing and development of this portion of the instrument is described in reference 5.

Table 1. Sensor Suite and Specifications

Hydrophone

low band, 2 to 250 Hz, 1,000 samples/second
medium band, 125 to 1,250 Hz, 5,000 samples/second
high band, 1,000 to 10,000 Hz, 25,000 samples/second
all bands, computer variable gain 0 to 42 dB in 6 dB steps

Accelerometer

VLF band (X,Y,Z), 0.025 to 0.66 Hz, 2.5 samples/second
low band (X,Y,Z), 2 to 250 Hz, 1,000 samples/second
all bands, hardware variable gain 0 to 42 dB in 6 dB steps

Meteorological Package

vane direction, relative to lubber line, instantaneous
wind speed, meters/second, instantaneous
compass, relative to north
air temperature, degrees C
relative humidity, percent
barometric pressure, millibars, 1 second average

Temperature Pressure Module

temperature, degrees C, 1 sample/10 seconds, 1 minute avg.
pressure, decibars

Acoustic Current Meter

current velocity two axis, 0 to 360 cm/sec, 10 min avg, 3%
water temperature, -2 to +35C, +- 0.05
tilt, 0 to 30 degrees, 10%
pressure, 0 to 1000 decibars, 0.5%
conductivity, 1 to 79 ms, 0.05 ms

Note: Sea cable instruments use SAIL protocol (ref 3). The system can be configured for any SAIL instrument.

Figure 1. The ARAMP buoy with meteorological tower deployed in pack ice during CEAREX. Helicopter used to transport equipment to remote site.

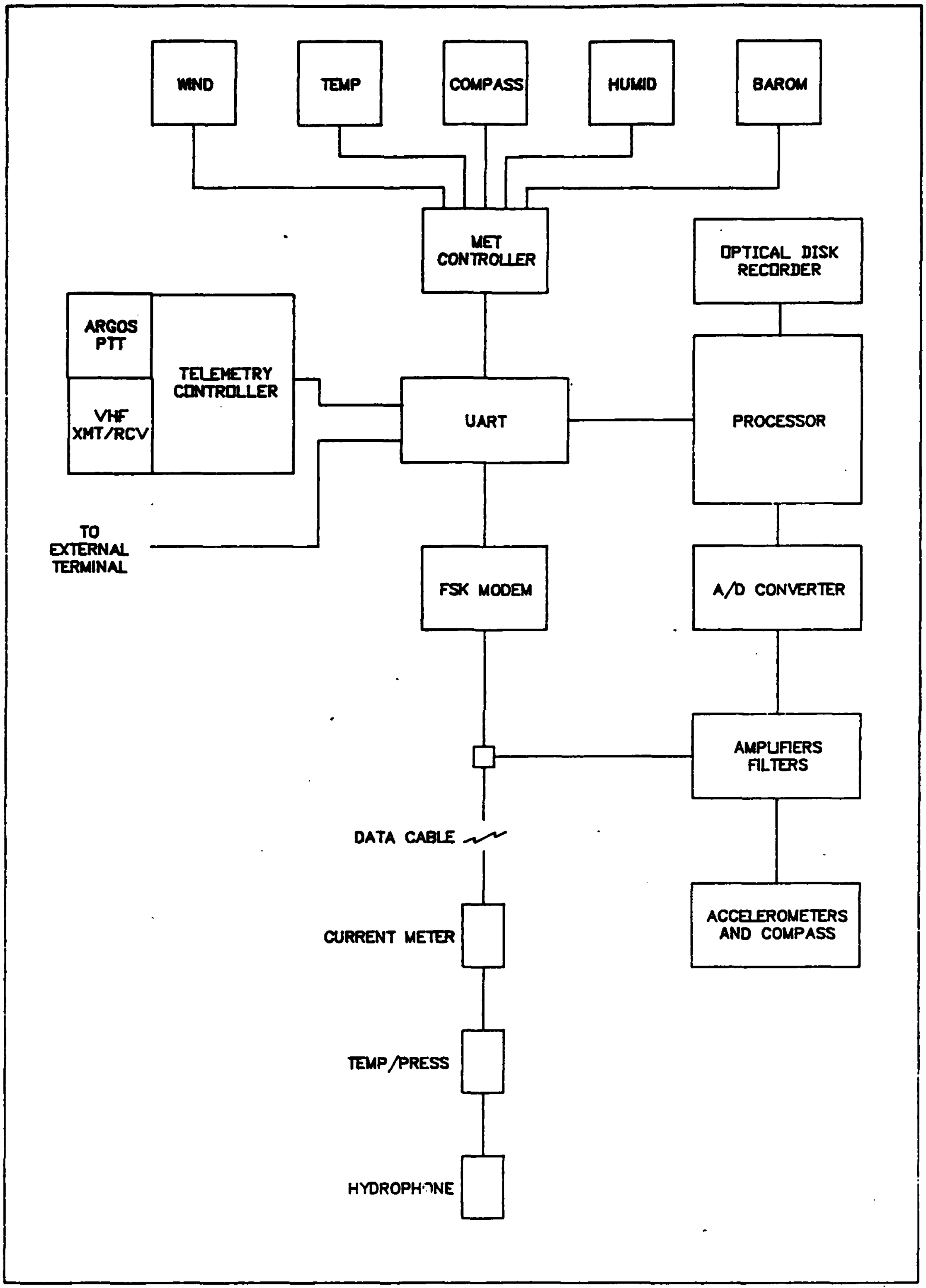

Figure 2. Block diagram of the system. The meteorological sensors are on the tower above the ARAMP pressure case, the current meter, hydrophone, and temperature/pressure module are connected to a sea cable.

3. CEAREX Problems

After the prototype system's deployment at Prudhoe Bay in 1987, a series of five units was manufactured for use during CEAREX in 1989. However, experiences during the prototype testing and subsequent requirements changes necessitated engineering changes and redesigns to the original instrument. As a result, the five units manufactured were quite different from the prototype and insufficient testing was performed which lead to problems during the CEAREX operations.

Details of the problems are outlined in appendix 1 which was written at the conclusion of CEAREX. A brief list of the problems follows:

- the optical disk recorder performed erratically due to problems related to temperature, power supply, and turn on/off protocol;
- FSK board power control was inoperative;
- incorrect RS-232 levels were used;
- incorrect capacitor type was installed;
- one solder bridge was found;
- the V20 CPU operates incorrectly at cold;
- wrong connector type was used on sea cable;
- sea cable rigging method was not suitable;
- no checkout procedures were provided;
- provision for keyboard input caused program to stop;
- incorrect interface was used between program modules;
- incorrect data format was recorded;
- inadequate support programs were provided.

As a result of the above, the author undertook to

- solve problems encountered during CEAREX;
- evaluate all aspects of the buoy's performance and make changes as necessary to achieve an operational system.

Described below are the tests performed and an outline of the problems identified and repaired followed by some improvements that were designed and implemented as part of the process of bringing the instrument to operational status.

4. Tests Performed

Bench

The system was set up on a laboratory bench so that it could be monitored during operation and many different tests were performed. Initially, only the digital portion was operated because the symptoms indicated that it would not run its normal acquisition program to completion.

In this mode, the causes of the basic operating problems were identified, design changes effected as necessary and the system retested.

As the digital problems were resolved, sensors or simulated inputs were added to allow analog portions of the system to be tested. This included for example connecting the hydrophone to the system with suitable audio signals air coupled from an amplified signal generator. Likewise, most of the stand-alone instruments that were used could be operated in the laboratory. Their outputs while different from that obtained in the Arctic served to verify that the system could control the instrument's operation and collect the data.

Freezer

A series of tests was performed using a low temperature freezer to evaluate the performance of the disk drives and the batteries at Arctic temperatures. The aim of these tests was to determine lowest temperature at which reliable disk operation could be obtained.

These tests were performed on two types of optical disk drive: a unit from NHance which is a commercial service drive, and a unit from Mountain Optech which is a variant of their ruggedized drive specified for operation to -20C. A summary of the tests performed is in appendix 2.

From these tests it was clear that it was necessary to reconfigure the internal framework of the ARAMP to take advantage of the warmth of the ocean water which surrounds it when deployed. To evaluate the success of this reconfiguration, internal temperature sensors were added and a series of tests was performed in a simulated Arctic environment at the army's Cold Regions Researoh and Engineering Laboratory (CRREL) in Hanover N.H.

CRREL

At CRREL, a cold room complete with water tank was used to perform tests of the modified ARAMP internal framework which were designed to determine what temperatures the optical disks would be exposed to in Arctic conditions. Details of the tests performed are in appendix 3. A full description of the process is in reference 5.

Simulated Field Tests

These tests were designed to operate the ARAMP in configurations as near as possible to those in a field deployment. Two tests were performed both of which used battery power and had ARGOS telemetry operational.

The first was a dock test that had the full buoy hull assembled and deployed off the WHOI dock. Due to the water depth however, neither the sea cable nor the instruments were installed. Also, the necessary method of suspending the unit precluded the use of the met tower.

The second test used the complete system with tower and instruments on land. The main hull was suspended on deployment tower (quadrapod) with the meteorological tower attached. The sea cable and instruments were also connected and operating.

These two tests served to confirm that no problems exist relating to interference between modules or to wiring or packaging in its deployed form.

Telemetry

A stripped version of the digital electronics was assembled and installed in the top floor of our laboratory with the antenna on the roof. Communication and data transfers were performed initially from a laboratory separated by two floors of the building then from a truck at various ranges from the building. Finally a small plane was chartered to try to determine the maximum range for successful operation.

Although problems were identified and solved during these tests, the range question is unresolved due to a problem during the flight test. The end of the contract funds prevented the flight test from being repeated.

5. Problems and Solutions

Optical disk

The problems relating to the optical disk were identified as:

- regulator and battery
- controller reset
- turn-on sequence
- temperature.

Regulator and battery

A photograph of a problem media indicated that a series of pits had been burned that were too small causing the system to try to re-use the location in subsequent operations. This resulted in a corrupted media which could not be read. The cause of this problem was current starvation which was cured by using a higher capacity battery and regulator.

The original regulator was a 78M05 driven by a Mallory PC-915 (lantern battery). In the new design, the main battery stack (12 Gel Cells no. GC 1245 in parallel) was used to drive switching DC to DC converters with over-specified surge and steady state current drive.

This redesign also apparently solved erratic problems such as disk eject at power on which resulted from a dip in the logic supply caused by the underspecified regulator.

Controller reset

Since the disk controller being used drew about 1 watt of power, a special adapter board was designed to allow it to be turned off when not in use. The adapter board however, did not apply a reset when the power was turned on resulting in unpredictable operation at power on. This was solved by adding a power up reset circuit to the adapter board.

Turn-on sequence

Occasionally the optical disk system would indicate a not ready condition at power up which was solved by sequencing the power at turn-on: first the drive then the controller must be powered.

Temperature

Initial cold testing indicated that the drives would operate in arctic conditions in the ARAMP buoy. More extensive tests showed that operation below about -5C was undependable if a long soak occurred between uses. Extensive tests and some redesign were performed in this connection - reported in reference 5.

The solution to this problem was to use a different disk drive and to redesign the interior frame to take advantage of the relatively warm ocean water surrounding the lower end of the pressure case. This necessitated a new disk mount, changed system and applications software, different cable routing and thermal insulation designed to retain the heat generated by the drive's own 25 watt dissipation. In addition, the power system was changed as described above. System drawings have been updated to reflect these changes. Figure 3 is a photograph of the system after these modifications have been performed.

Other hardware problems

A collection of minor hardware problems were identified during laboratory testing of the system's operation. Although some are trivial problems, many would inhibit successful field operation. Where applicable, documentation changes have been made. The problems are briefly discussed below.

V20 chip

To achieve faster processing, the CPU chip (an 8088) was replaced with a NEC V20. Our philosophy of achieving cold operation has been to use commercial temperature (0 to 70C) range chips and select for cold operation through extensive cold testing. Our experience has been that few failures occur. In the case of the V20 chip, several samples failed to operate, so we deduce that the industrial range (-55 to 125C) must be used.

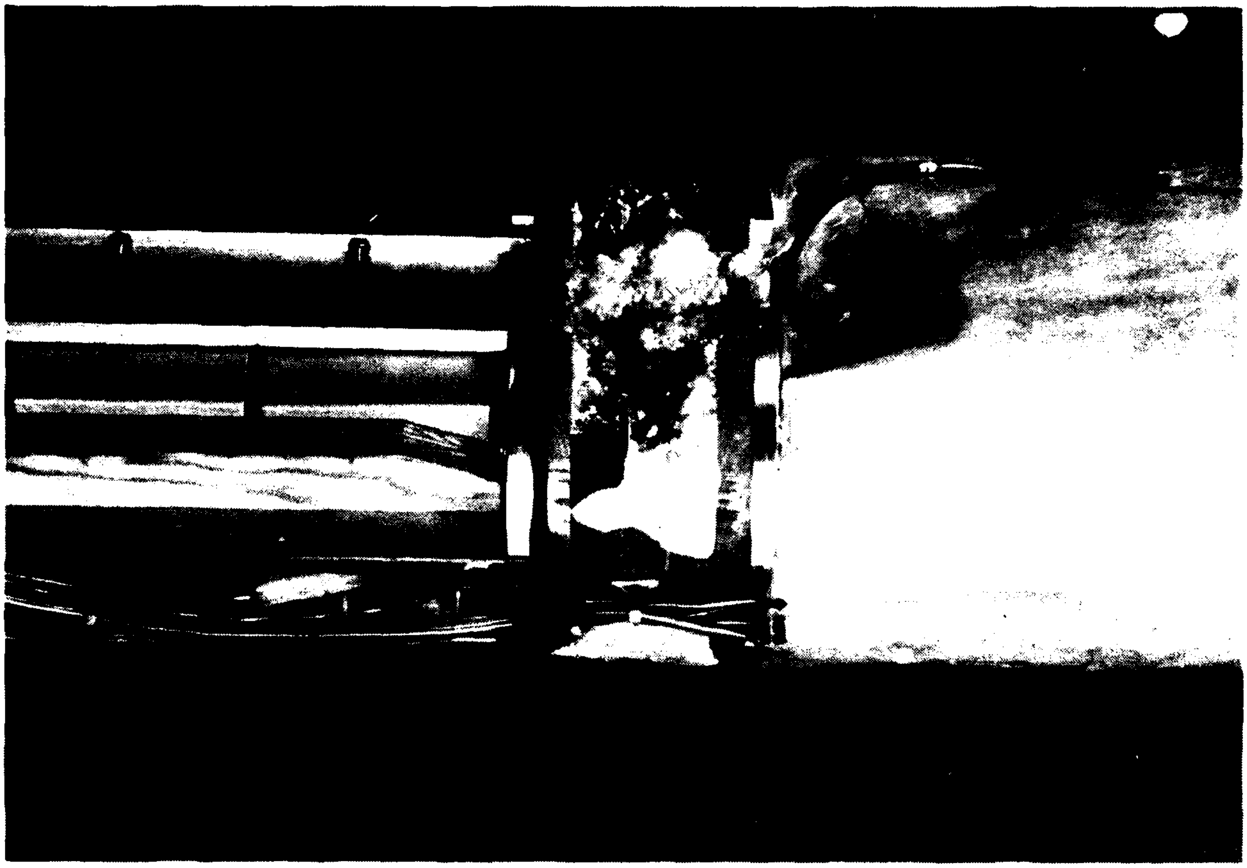

Figure 3. Picture of the new disk portion of the system showing lower portion of the main electronics and the insulation surrounding the disk itself.

Serial interface

Some of the serial interface lines were pulled to the wrong rail when disconnected. As a result, when the external cable was disconnected, it appeared that characters were being received thus preventing the acquisition program from running.

The integrated circuit that interfaced to the operator's console was a logic level device driving RS-232 levels. This works for some time, but eventually dies due to excessive current through the input diode. This is solved by installing a current limit circuit.

A/D pull-ups

Some of the A/D boards had pull-up resistors omitted on the A/D select input. This caused the acquisition to run very slowly in the cold. Occasionally a cycle that should take a few seconds will take several minutes to complete.

Watchdog capacitor

The system's watchdog circuit is used to restart acquisition after each cycle. During construction, metal foil capacitors were used instead of ceramic types leading to a much smaller capacitance in the cold. As a result, the reset pulse was too narrow to actually reset the processor.

VHF data telemetry

The local oscillator used in the mixer which moves the data telemetry signal in to the FM band was found to be feeding in to the FM receiver swamping the received signal. Attenuation of the oscillator signal solves the problem.

FSK board

The FSK board in the instrument was found to have no connection to the power control FET's gate. As a result the FSK board was not always powered when it should be. A wire modification to the board solved the problem.

Software

As for the hardware above, many software problems were identified during testing. Many would prevent useful system operation; all have been corrected. The major items are discussed below.

ARGOS message

The software to pack the data for the ARGOS message did extensive bit packing to make efficient use of the 32 bytes but did no limit checking. As a result, out of range or incorrect data could lead to apparent legal values rather than setting the transmitted value to one of the limits.

The coding of the algorithm used to pack the computed FFT's contained errors. The resulting coded FFT data was meaningless. Also some errors were found in the bit packing of the scalar values.

Long time series file

A coding error in the creation of the data buffer for the long time series measurement of the hydrophone signal caused alternate bytes to be zeros. Furthermore, the time represented by the data was not continuous due to resultant buffer overflow.

VLF data file

The one-half hour data file of the very low frequency acoustic signal was corrupted by turn-on transients. No start-up time was allowed to deal with the large time constant of the low frequency filter components.

Block misalignment

Two program modules were found to define a series of variables differently. The two were changed to be identical.

Interrupt trap halt

Occasionally the acquisition program was found to fail leading to a restart after the watchdog time. The period of repetition was variable, but on the order of days. The character of the failure changed during the program changes that were performed, but it was not eradicated.

6. Additional Improvements

During the reconfiguration necessitated to solve the disk problem, some other changes were made to effect incremental improvements in performance. These are discussed briefly in the following.

Wiring changes

Since all modules in the system are now powered from the one main battery, the power wiring was changed. The disk power is now available on the control panel with a separate switch and fuse.

Battery

To take advantage of the increased interior room available as a result of the changes, two additional 4 AHr batteries were added to the battery pack bringing the total to a nominal 56 AHr. A positive lock was installed to prevent the cells from moving even if the system receives a severe shock. Stiffeners were added to the frame in the middle of the battery section to prevent flexing due to the weight.

Engineering measurements

During the changes made for the new disk configuration, an engineering measurement channel was added using the main system A/D converter. In addition to the temperature sensors, various voltages are scaled to be read by the processor.

Wheels

To ease the insertion and removal of the chassis in the pressure case, teflon washers were mounted on the extreme bottom section of the frame to act as wheels. This makes the chassis easier to move and also prevents generation of metal shavings.

Handling equipment

Some difficulty was experienced in moving the ARAMP when completely assembled. It was marginally too heavy for two people to handle, and there was no hand hold for more than two people. Also no convenient tie point was available for helicopter slinging. These problems were solved using the following:

- special eye bolt with sling ring
- choker straps
- lengths of pipe.

The eye bolt is installed in place of one of the top cap securing bolts during handling. It is fitted with a shackle and sling ring which is sized to accept one of the pipes for manual carrying. The choker strap is sized to be used at the lower end of the pressure case during manual carrying also in conjunction with a pipe. The two pipes are at convenient carrying height for most people allowing four people to share the load during manual handling.

For helicopter slinging, the load hook is connected to the sling ring which is installed with the shackle and special eye bolt. This provides a secure lifting point which supports the buoy nearly vertical during flight.

Telemetry recovery programs

During telemetry data transfer, blocking and check characters are added to the files. When the decoded data is stored, it is necessary to check the files for integrity and reformat them to create an image of the transmitted file. A series of programs was written for this purpose.

Data plot programs

During system testing it was necessary to evaluate the content of data files to determine if the various sensor systems were functioning as desired. A series of programs was written to convert the recorded binary data and to plot it for CRT or hardcopy display.

Deployment procedures

Due to the complexity of the system and the number of subsystems, it was necessary to create a set of formal procedures to perform during predeployment checkout. This ensured that no modules were omitted in the checkout and also made good use of personnel time since the tests were performed in a logical sequence. The procedures appear in appendix 4.
Along with these procedures, is a series of test programs which is contained in the instrument or is loaded during testing.

7. Sample Data

Teething problems with the ARAMP units prevented full operation during CEAREX however, sufficient data were collected to prove that the system's hardware design is valid and that one version of an acquisition program functions as required.

During CEAREX, one ARAMP was deployed for test purposes near the acoustics ice camp. Although it did not function continuously and was too near the camp to collect meaningful data, some samples are presented to demonstrate the system's capabilities.

The data are all taken from the following acquisition cycles:

- 9 April 1989 at 12:00
- 15 April 1989 at 20:00.

Figures 4, 5, and 6 show three pairs of spectra taken during the first, second, and third part of the hour in the 9 April record. Figures 7, 8, and 9 show time series of the meteorological, temperature/pressure modules and acoustic current meter data respectively during the same period. Figures 10 through 16 show the corresponding data for the 15 April record.

Due to programming errors, sensor time series data and ARGOS telemetered data collected during CEAREX were not valid. In both cases however, the hardware functioned correctly. The necessary software changes have since been performed so that all aspects of the original program design now function correctly.

During system testing, laboratory tests were performed using an audio tone amplified and air coupled to the system's hydrophone. Data collected in this way enabled the complete system to be checked including the hydrophone, preamplifier, variable gain amplifiers, anti-aliasing filters, acquisition software and FFT routines. This was not a calibrated test (which was performed before CEAREX) but simply a confirmation that all elements of the system function together after the many changes that have been made. Figures 17 through 20 show the results of these tests.

8. Status

An itemized list of the status of the various pieces of equipment used as part of ARAMP appears in appendix 5.

In summary, the design of the ARAMP is stable. All changes discussed above have been performed on all five ARAMP units except for the disk design changes and the reconfiguration to position the disk at the bottom of the unit which have been performed on two units only.

The units have been packed and stored in our warehouse until needed. If a deployment is planned, support will be required to reassemble and recommission the ARAMP's and to replace any needed items that were lost during the CEAREX haulback.

9. Recommendations

Although the design is stable, the systems have not been used to perform real field measurements. It is recommended that they be deployed in order to complete the process of evaluating just what the instrument measures. For example, analysis of the spectra or the time series data may reveal biases or spurious signals that are not apparent when observing simulated data.

Documentation which currently exists includes electronic and mechanical drawings, software listings including brief descriptions of library routines, and deployment preparation procedures.

This level of documentation is adequate for personnel who have been working with the equipment, but not for untrained personnel nor trained personnel if they work on other projects for a period of time. If any likelihood exists that these units will be used in the future, it is strongly recommended that more complete descriptive documentation be written. Appendix 6 gives a suggested outline of what is recommended.

Current energy usage does not allow the system to be used for extended periods of time. With the current acquisition plan, the data capacity is the limiting factor. If a different plan is devised, changes may be needed in the power system including possibly solar charging.

The telemetry receiver is based on a laptop computer to make it suitable for use on helicopters. The present design uses a system with flexible disks which limits data the throughput rate. To improve performance of the system, it is recommended that the computer be changed to a hard disk based system along with attendant system changes.

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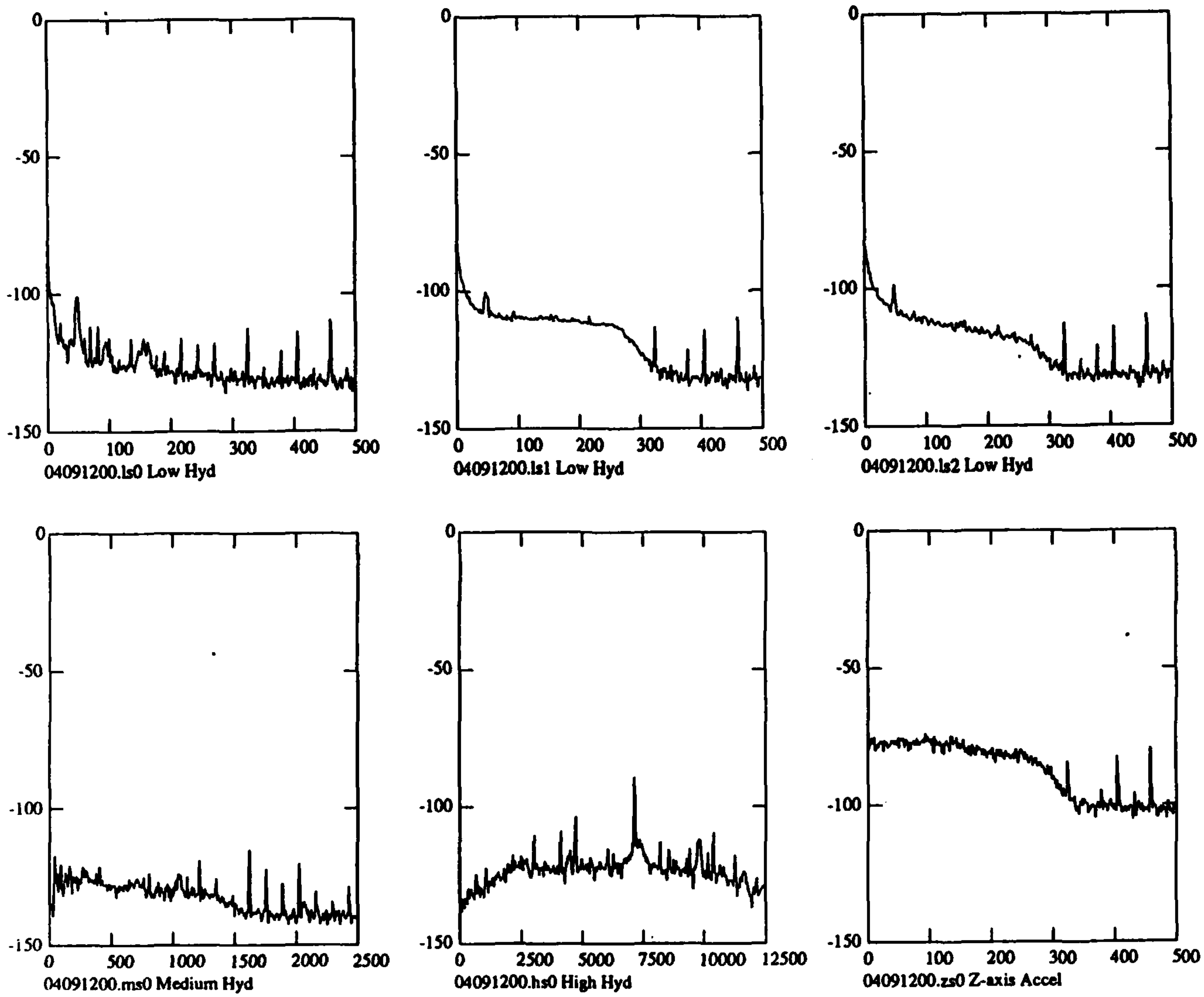

Figure 4. CEAREX spectra acquired during the first 18 minutes of the hour 9 April 1989, 12:00. The spectra are acquired and calculated in pairs: a low and hydrophone with each of a medium band hydrophone, a high band hydrophone and a z-axis accelerometer. The vertical axis scale is decibels, horizontal axis is Hz.

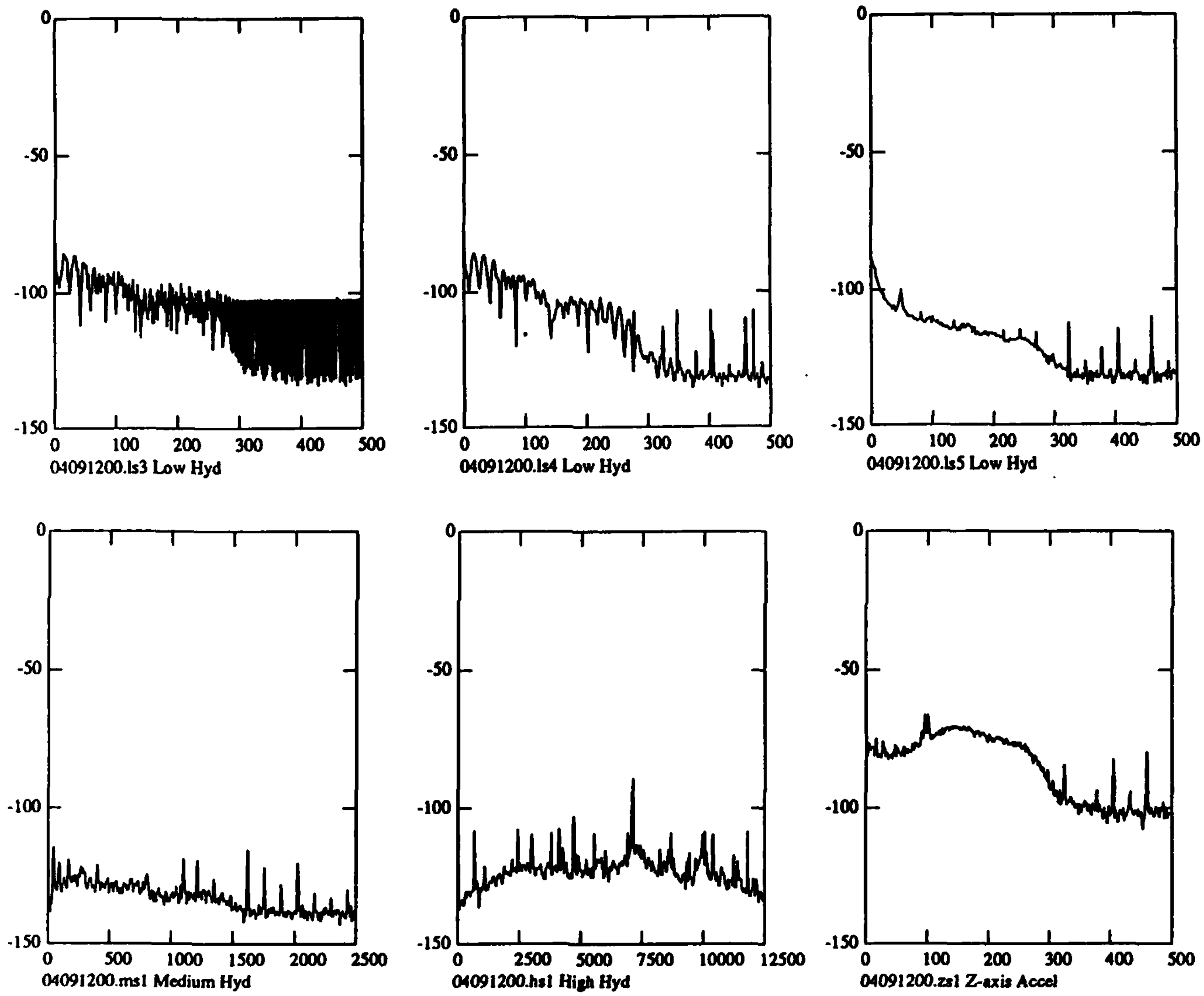

Figure 5. CEAREX spectra similar to figure 4, acquired during the second 18 minutes of the hour.

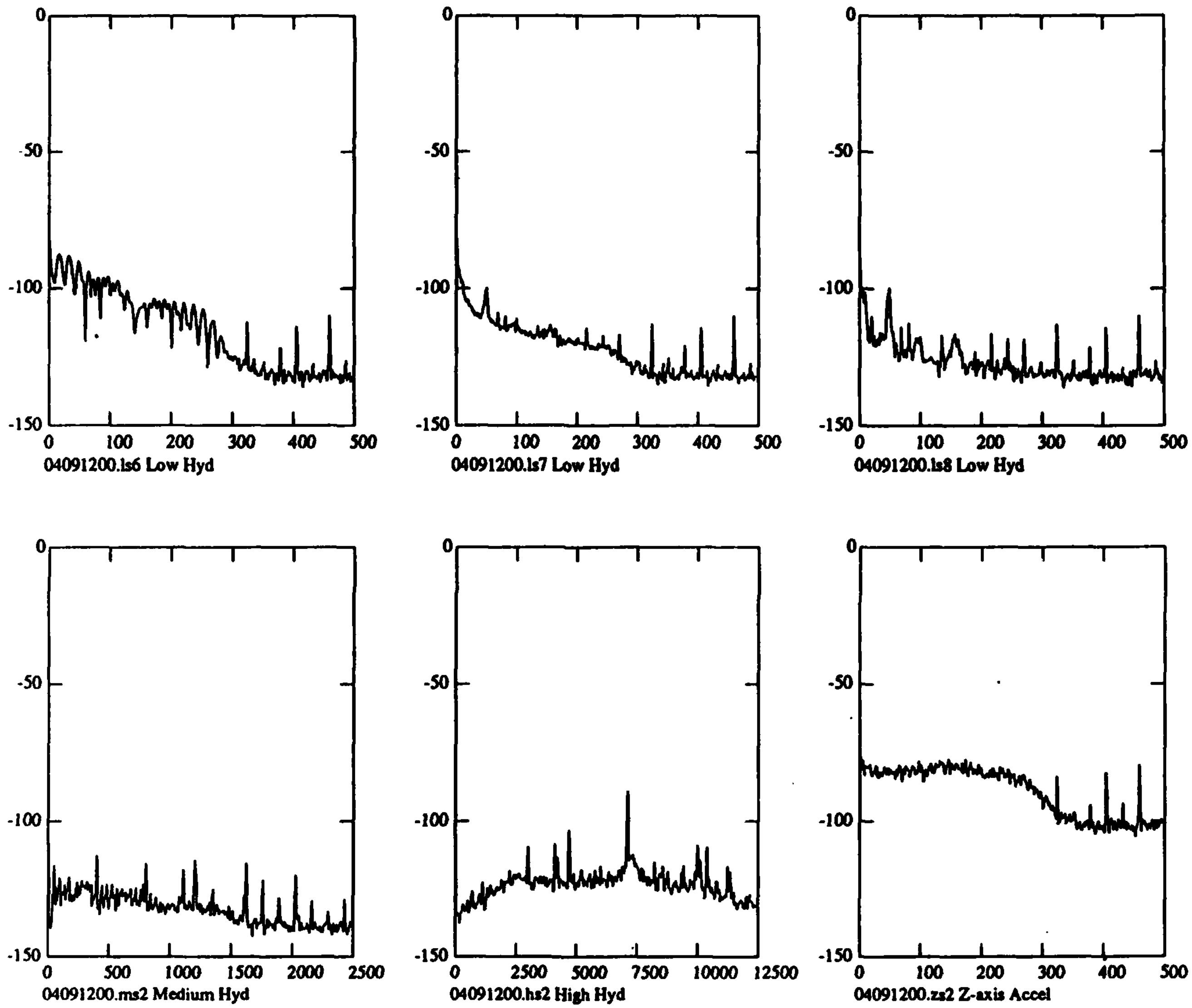

Figure 6. CEAREX spectra similar to figure 4, acquired during the third 18 minutes of the hour.

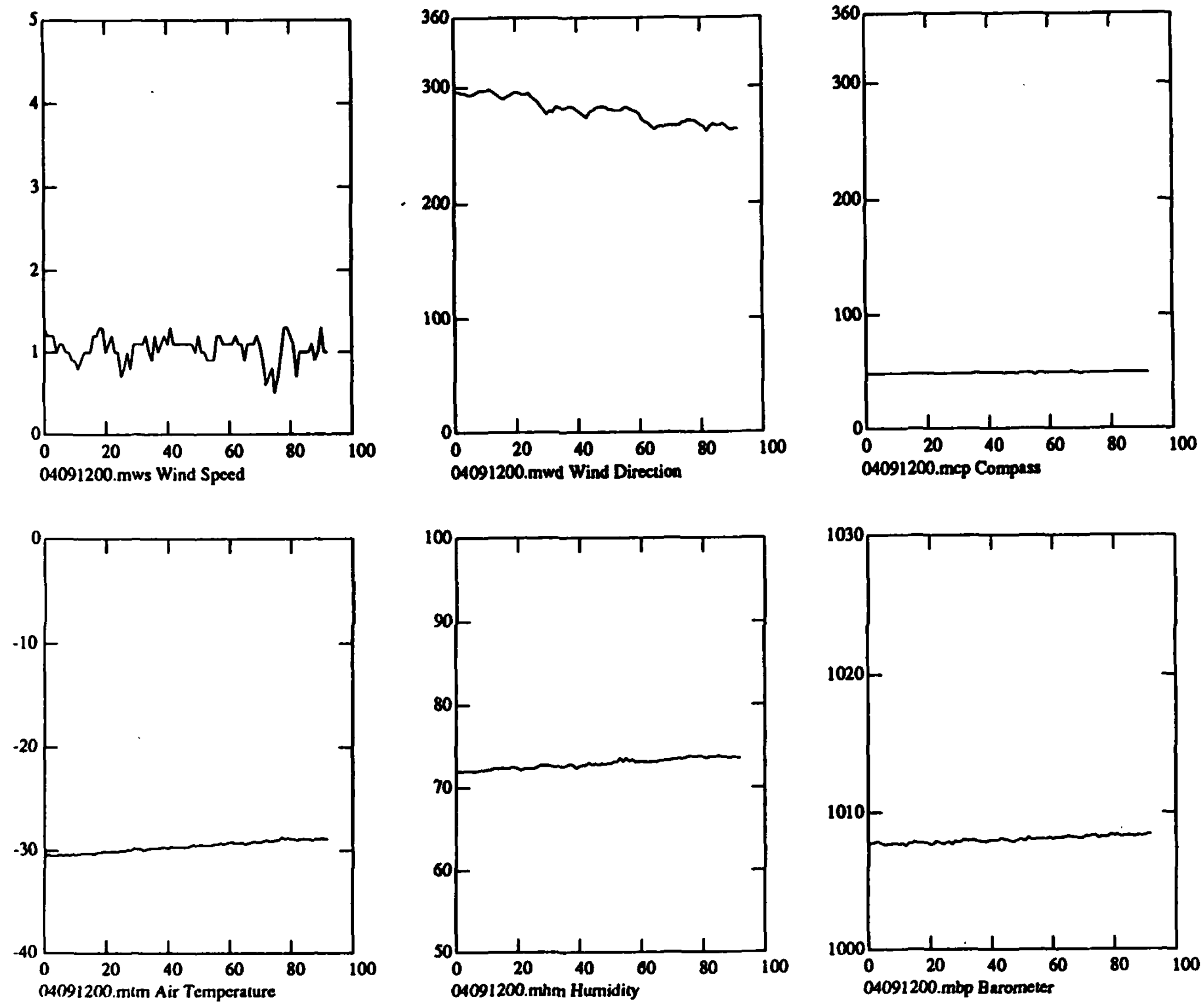

Figure 7. CEAREX meteorological data acquired over a 90 minute period starting at 12:00 9 April 1989. Vertical axis units are as given in table 1, horizontal axis is minutes.

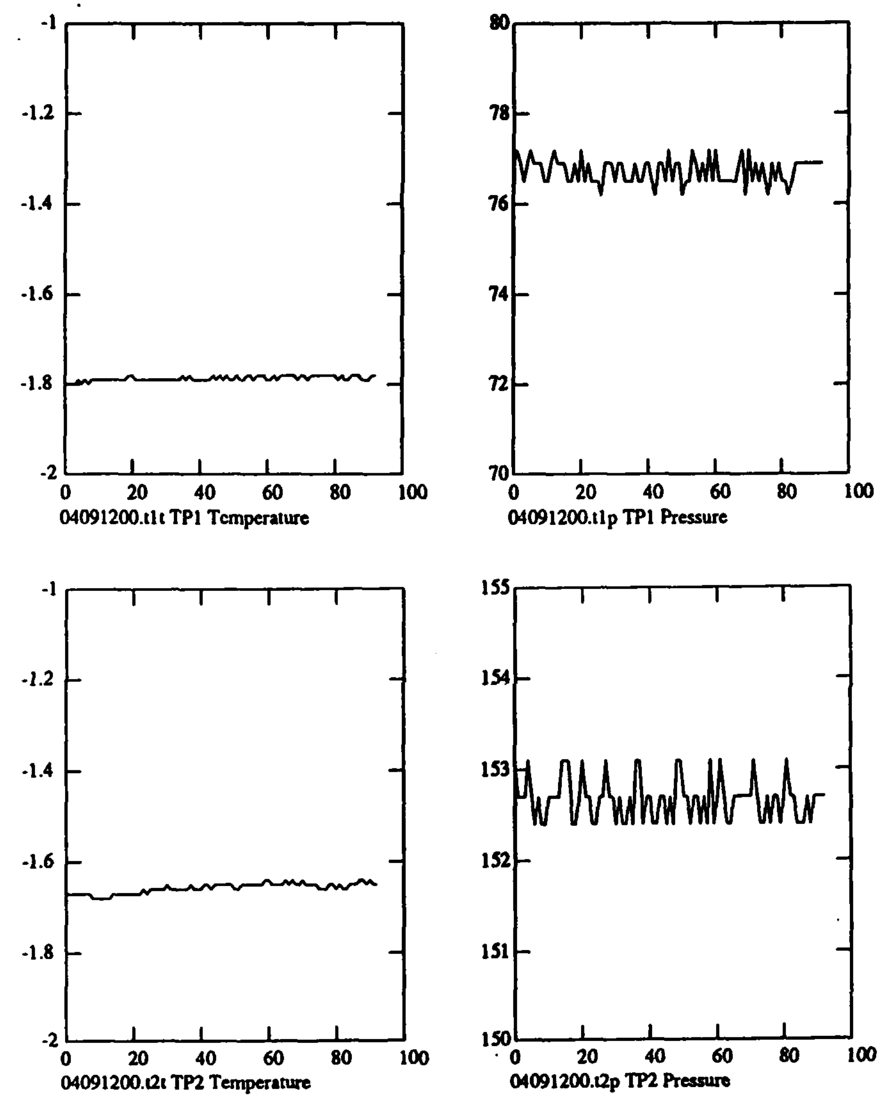

Figure 8. CEAREX temperature/pressure data from the two TP modules on the sea cable. Data acquired over a 90 minute period starting at 12:00 9 April 1898. Vertical axis units are as given in table 1, horizontal axis is minutes.

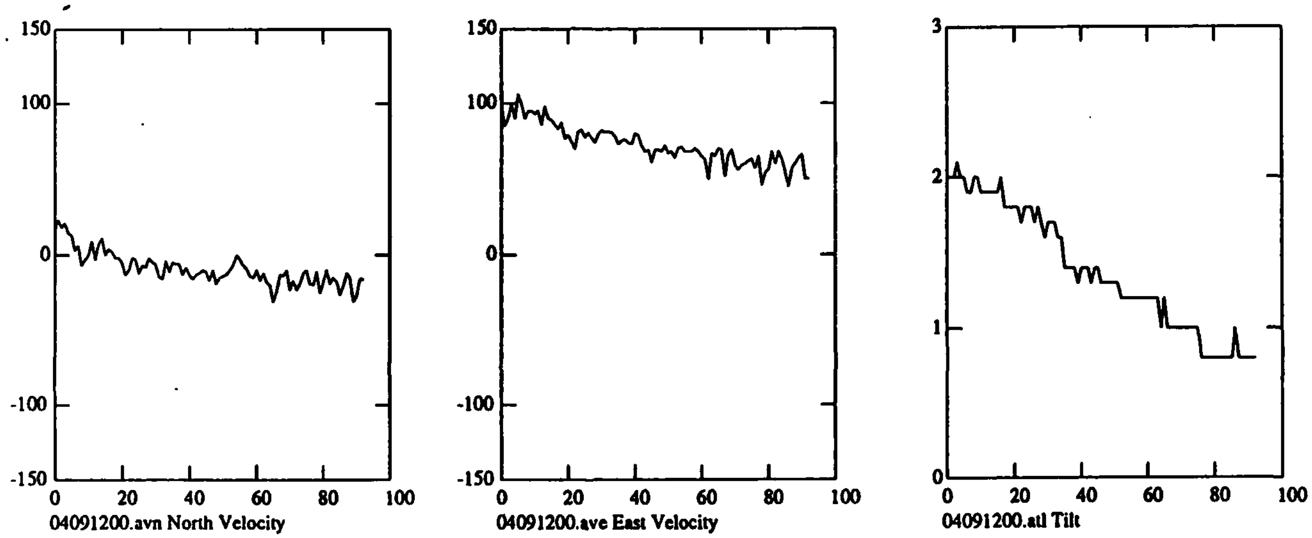

Figure 9. CEAREX acoustic current meter data acquired over a 90 minute period starting at 12:00 9 April 1989. Vertical axis units are as given in table 1, horizontal axis is minutes.

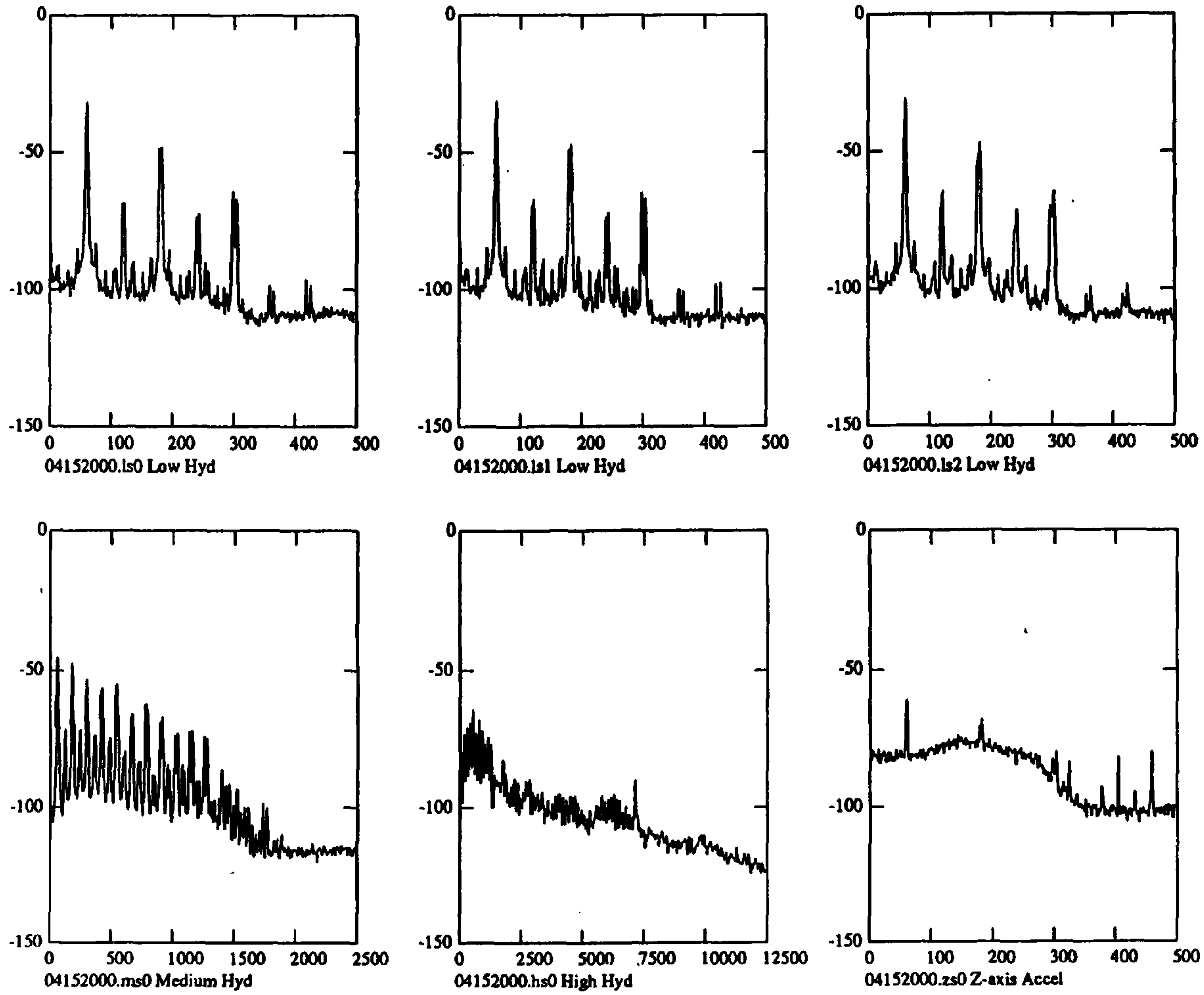

Figure 10. CEAREX spectra acquired during the first 18 minutes of the hour 15 April 1989, 20:00. The spectra are acquired and calculated in pairs: a low band hydrophone with each of a medium band hydrophone, a high band hydrophone and a z-axis accelerometer. The vertical axis scale is decibels, horizontal axis is Hz.

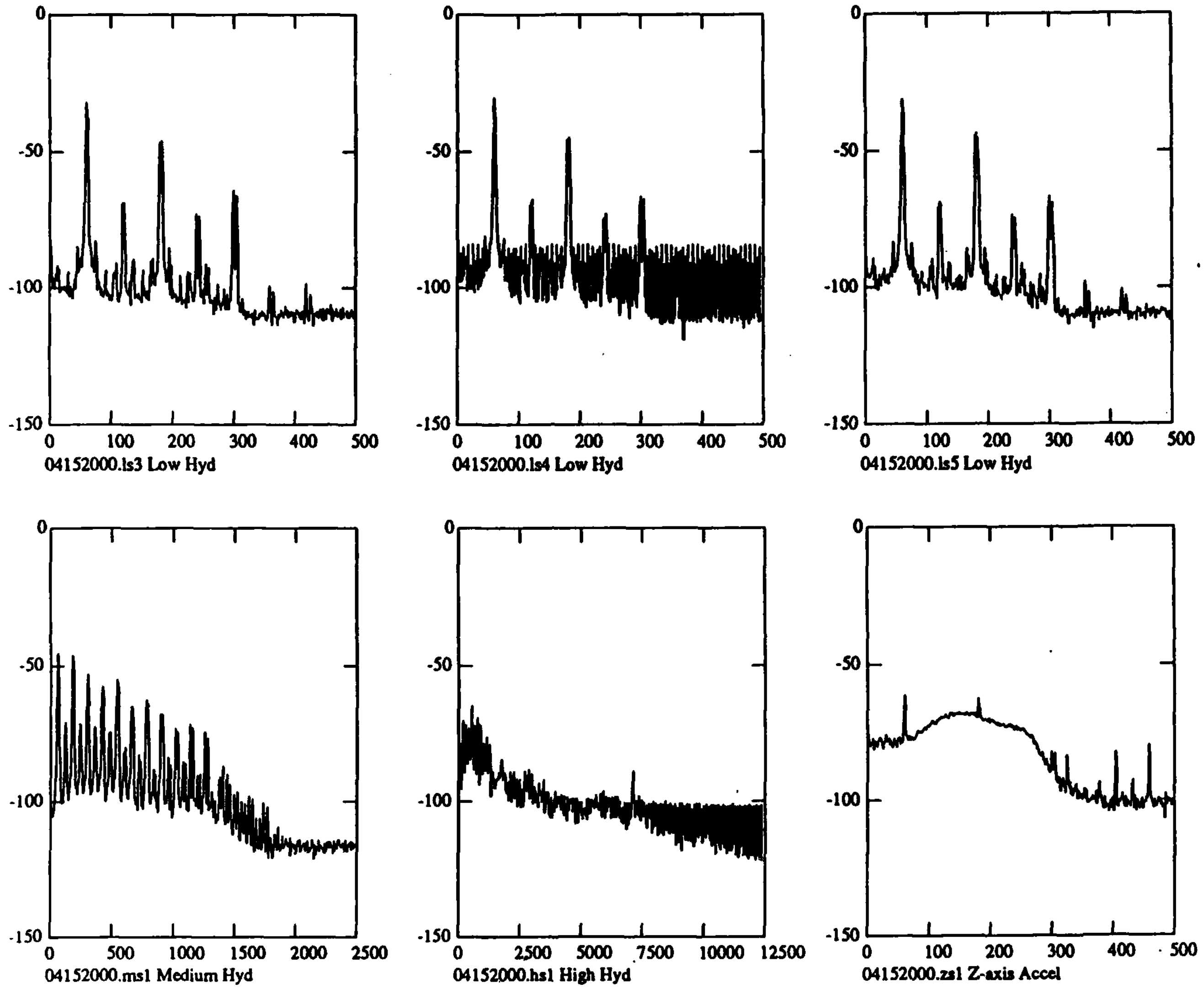

Figure 11. CEAREX spectra similar to figure 10, acquired during the second 18 minutes of the hour.

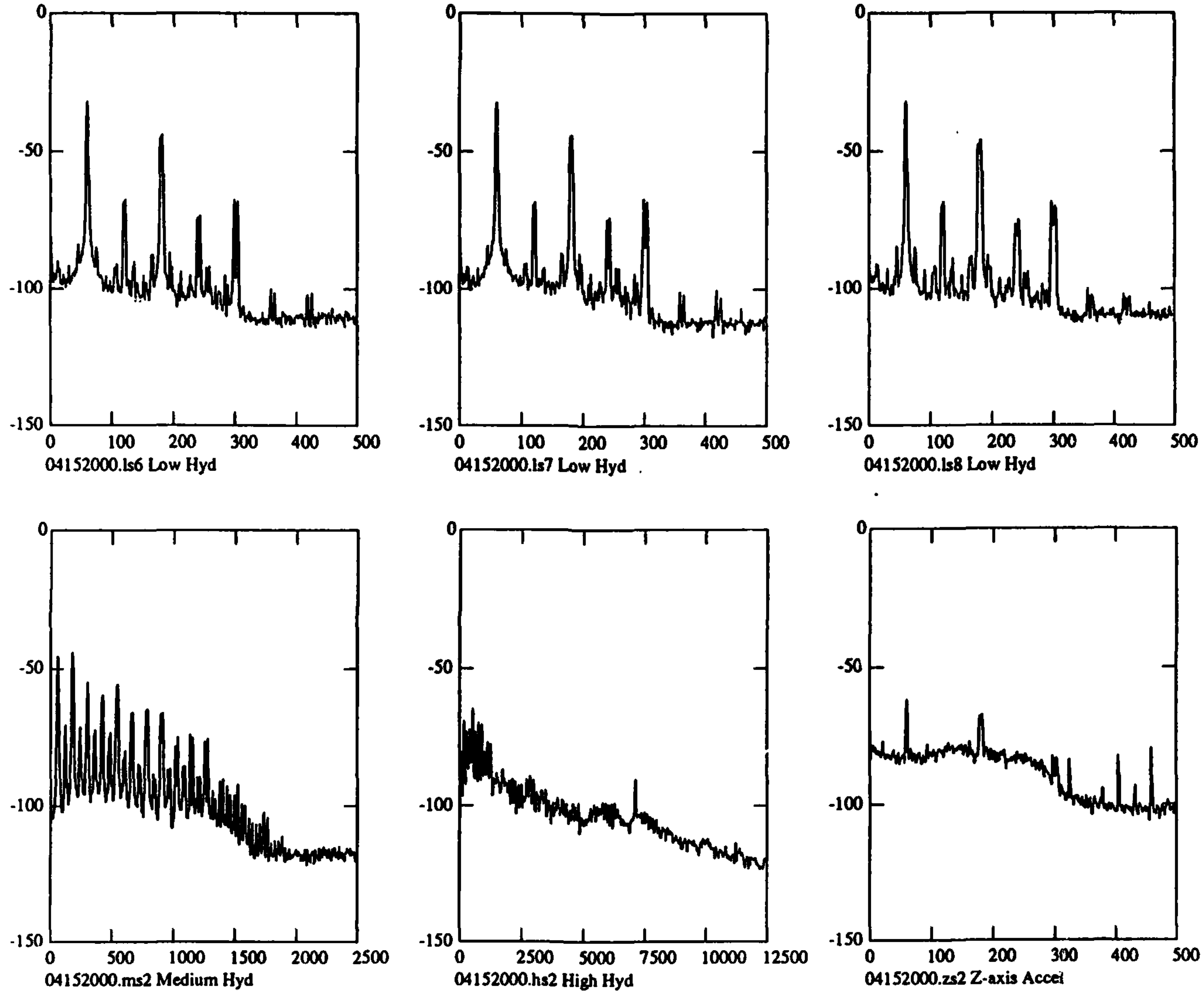

Figure 12. CEAREX spectra similar to figure 10, acquired during the third 18 minutes of the hour.

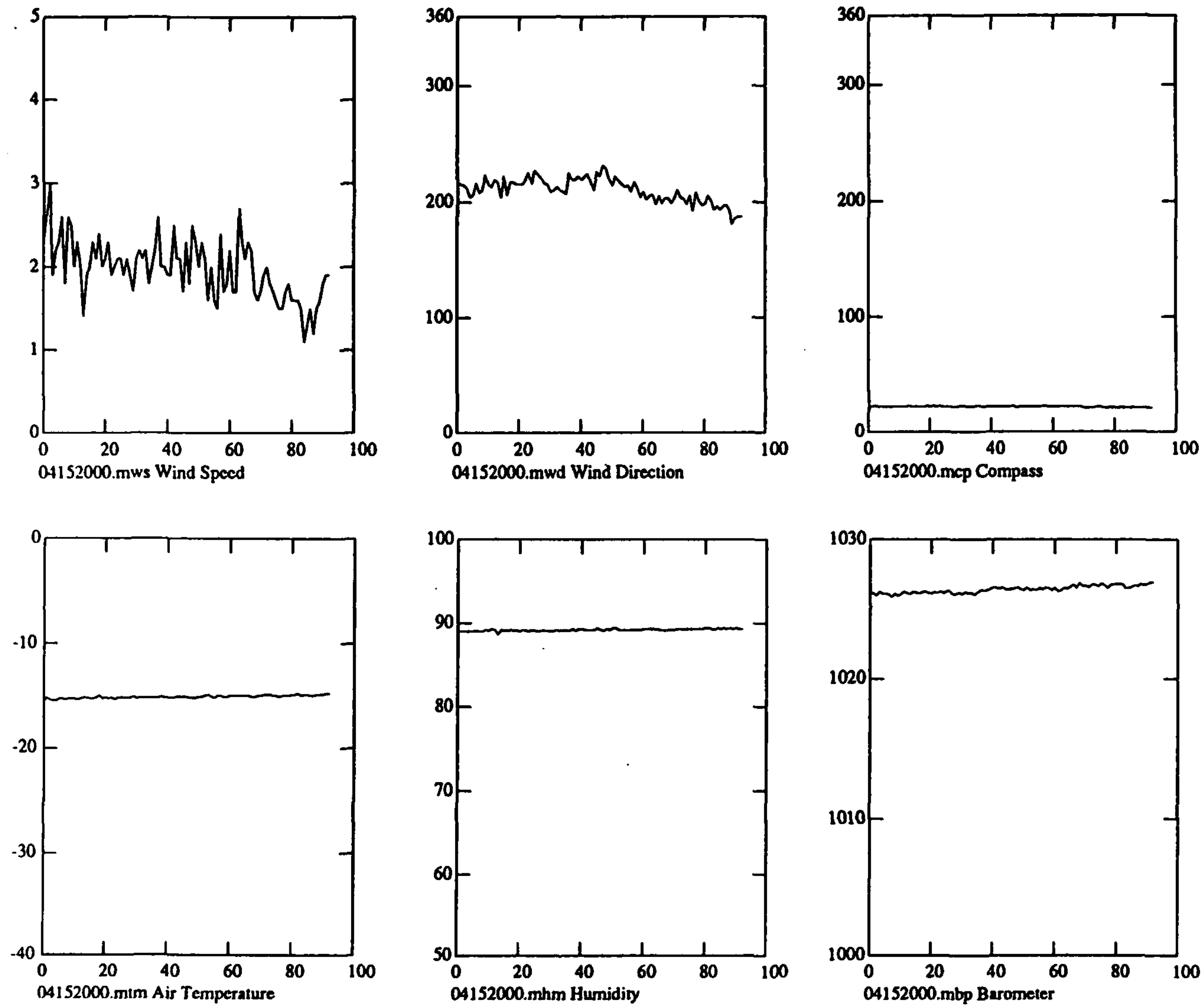

Figure 13. CEAREX meteorological data acquired over a 90 minute period starting at 20:00 15 April 1989. Vertical axis units are as given in table 1, horizontal axis is minutes.

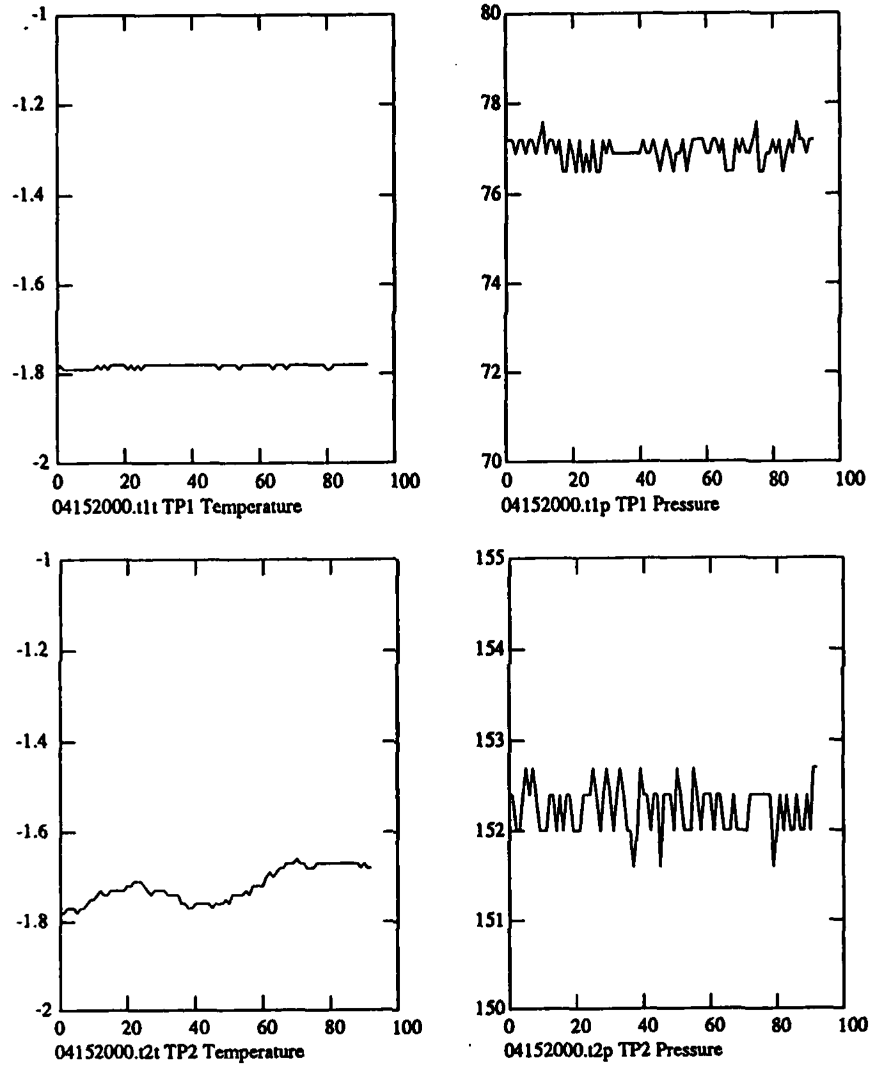

Figure 14. CEAREX temperature/pressure data from the two TP modules on the sea cable. Data acquired over a 90 minute period starting at 20:00 15 April 1898. Vertical axis units are as given in table 1, horizontal axis is minutes.

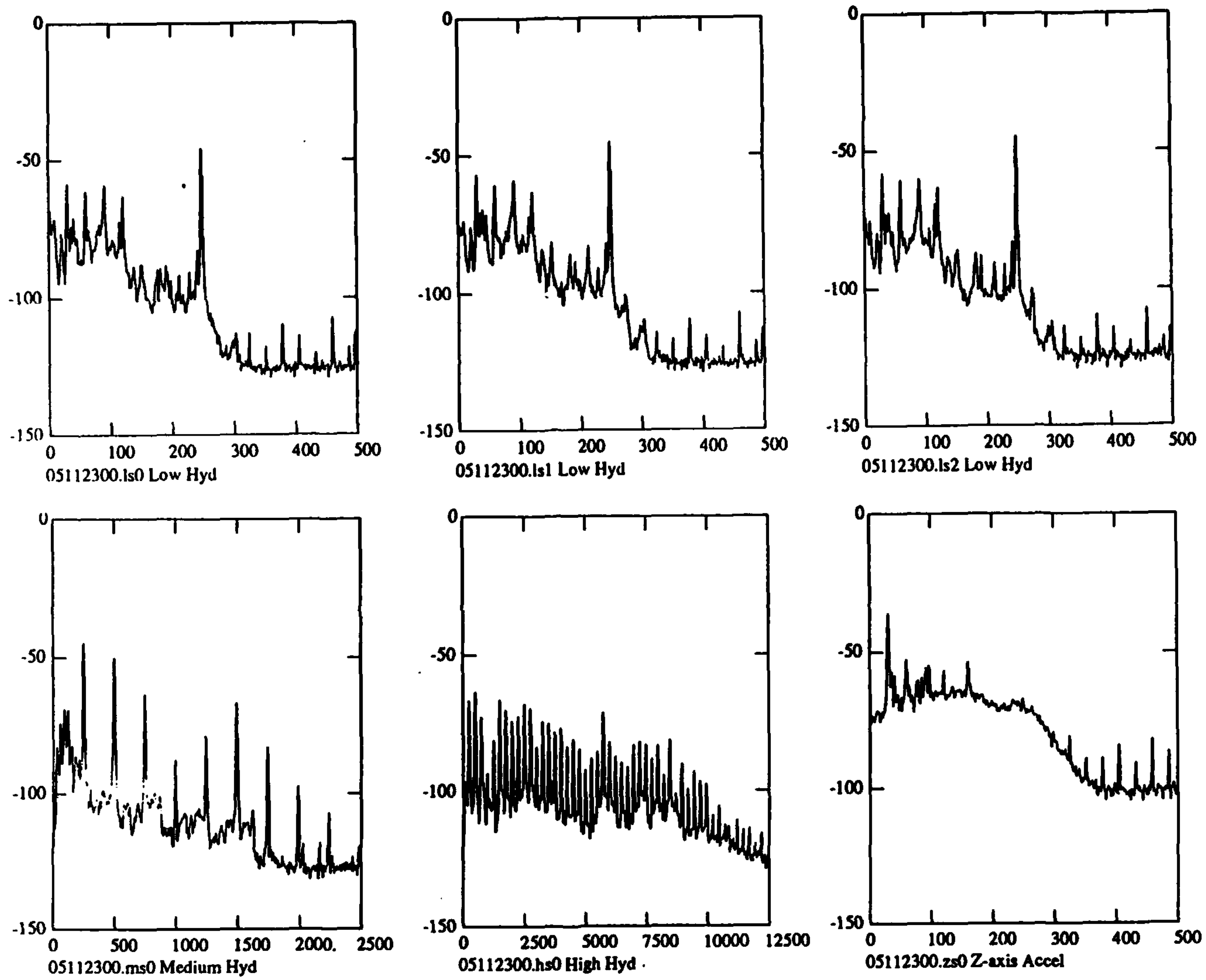

Figure 15. Laboratory spectra with a signal generator sine wave output air coupled to the system's hydrophone. Signal generator set to 250 Hz, first 18 minutes of the hour.

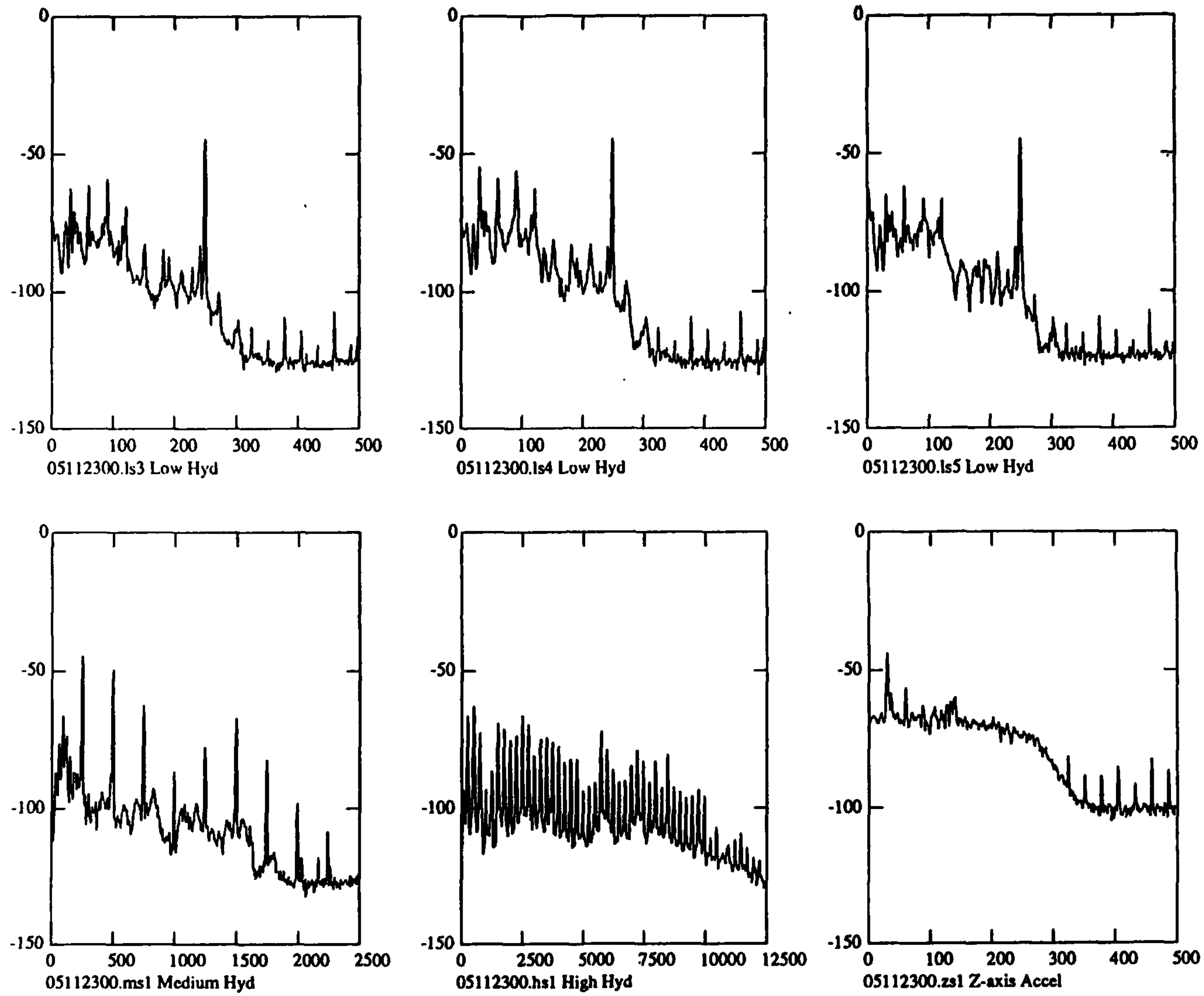

Figure 16. Same as figure 15, second 18 minutes of the hour.

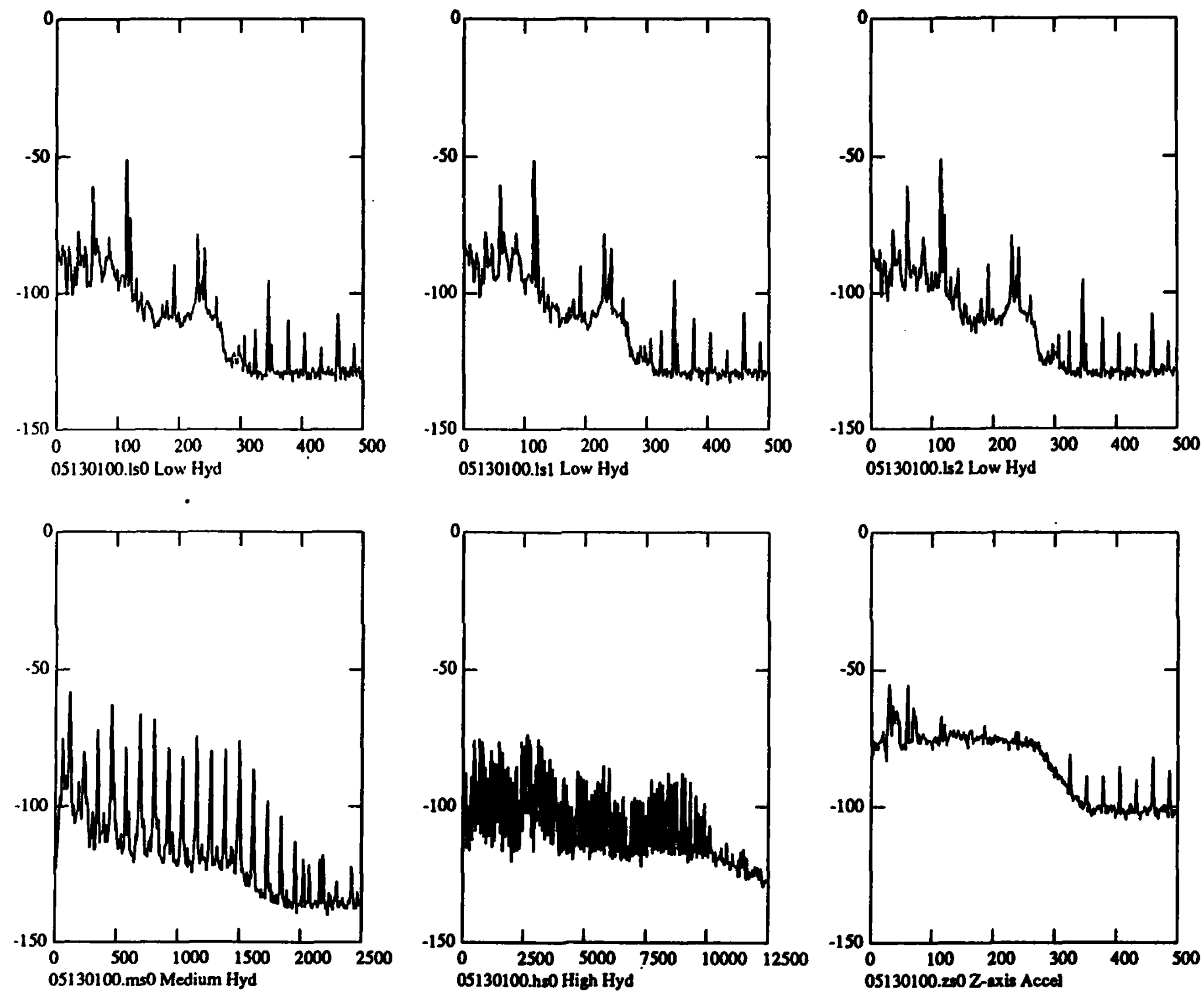

Figure 17. Laboratory spectra with a signal generator sine wave output air coupled to the system's hydrophone. Signal generator set to 100 Hz, first 18 minutes of the hour.

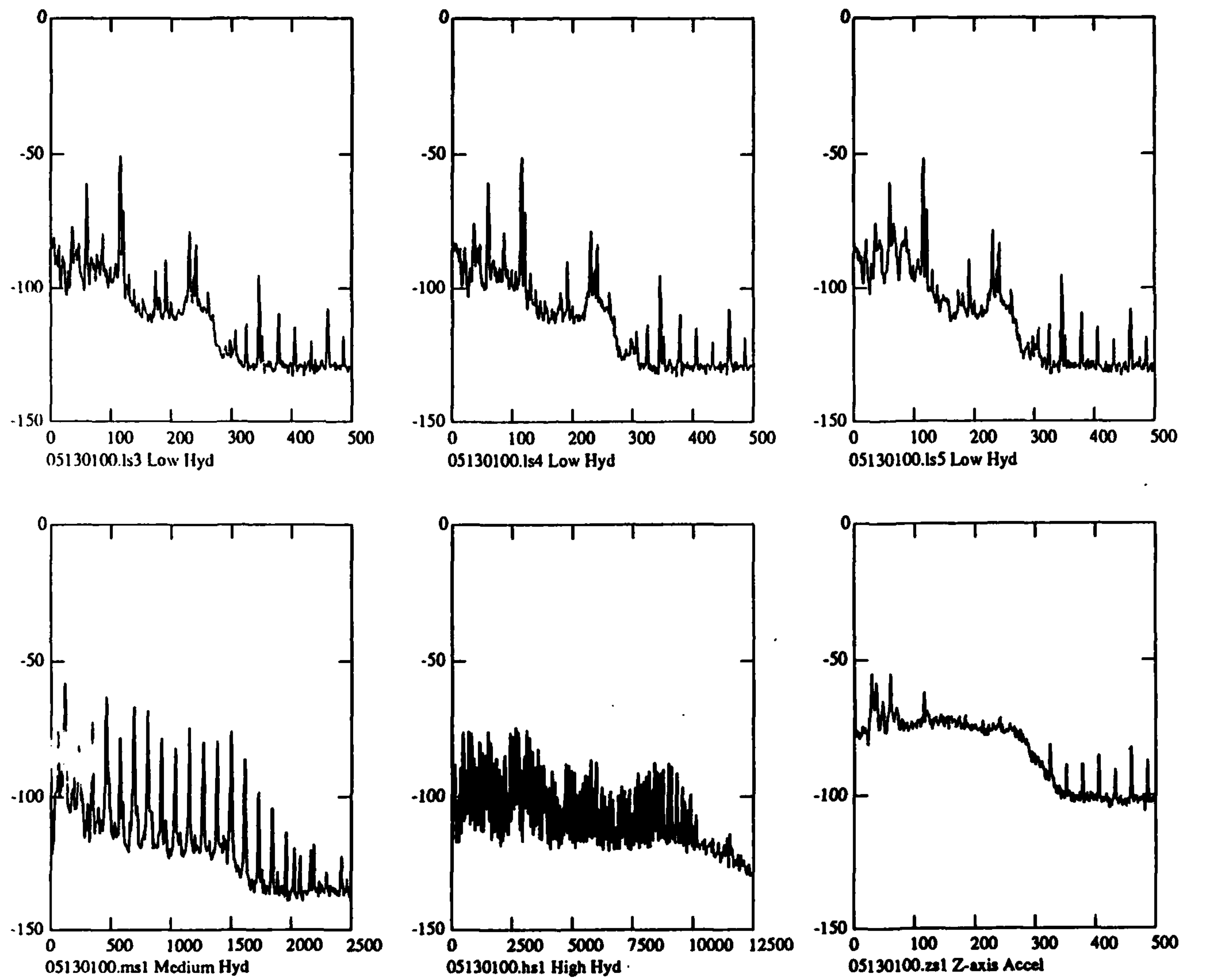

Figure 18. Same as figure 17, second 18 minutes of the hour.

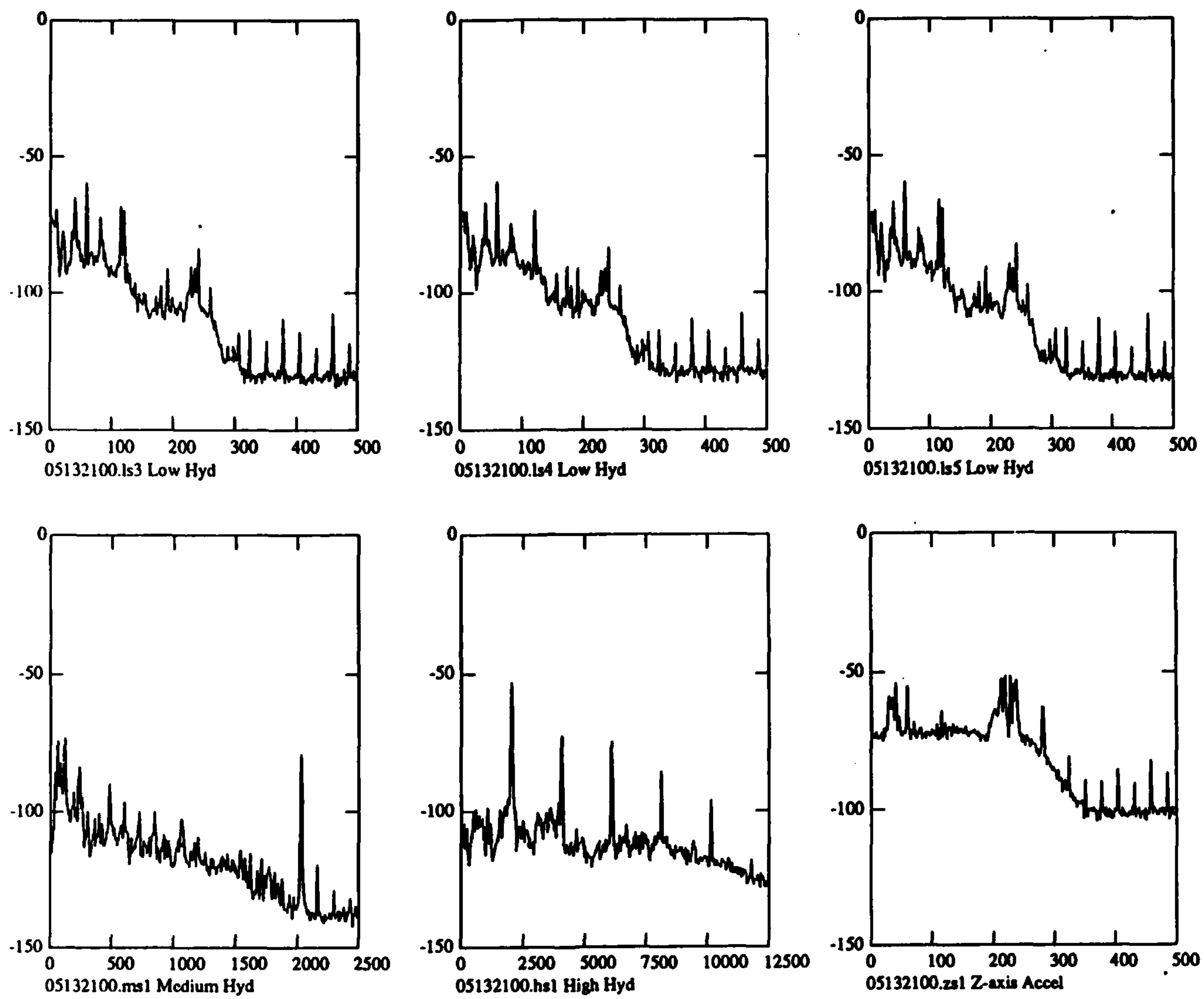

Figure 19. Laboratory spectra with a signal generator sine wave output air coupled to the system's hydrophone. Signal generator set to 2000 Hz, first 18 minutes of the hour.

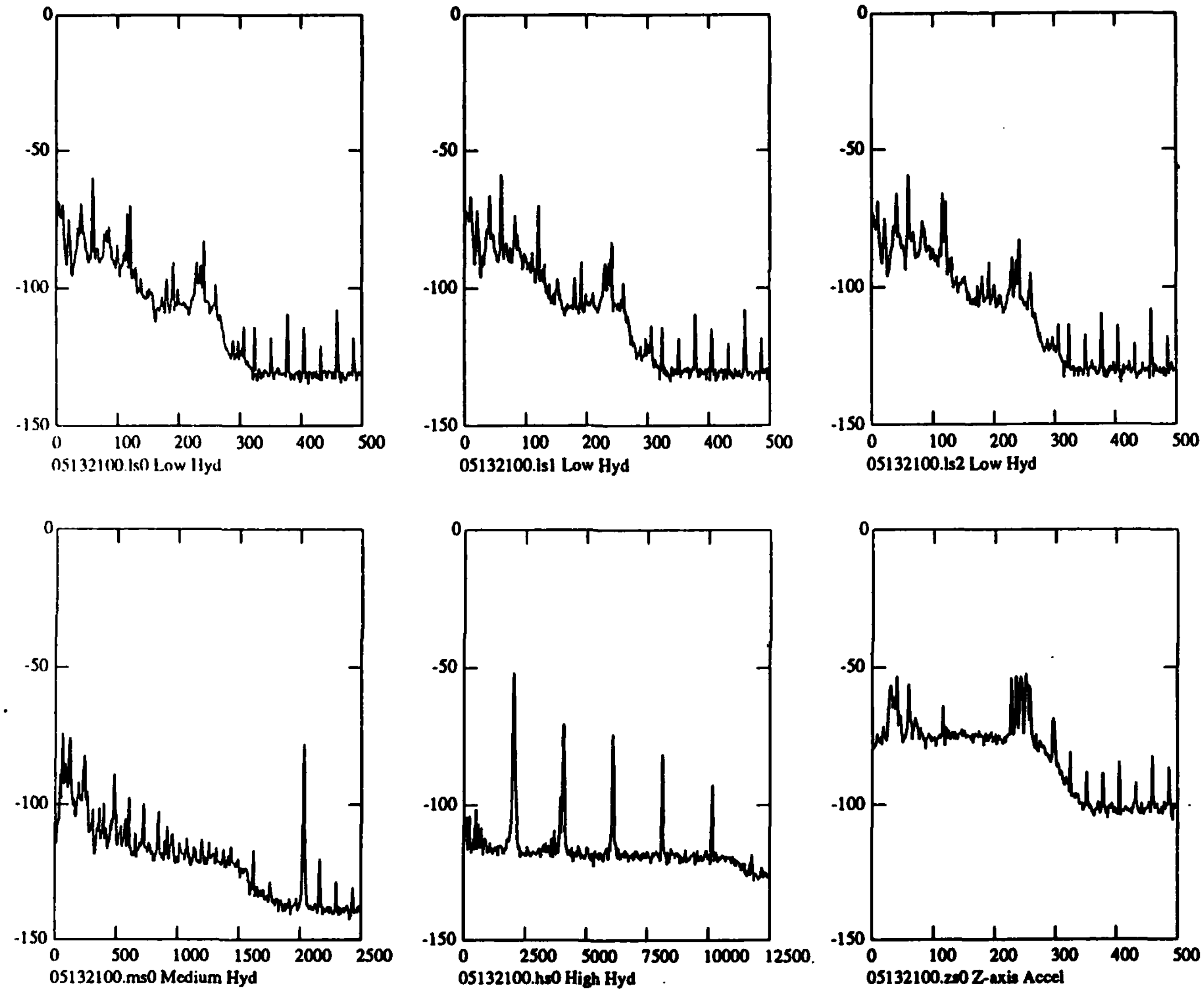

Figure 20. Same as figure 19, second 18 minutes of the hour.

Appendix 1. ARAMP Preliminary Engineering Report

ARAMP Preliminary Engineering Report
19 April 1989

Summary

Although not planned, our time was primarily spent debugging a new instrument. The first couple of days, we did simple tests to check what we thought was an operational instrument. When it became apparent that there were problems, we settled in to attacking them with some success. However, ARAMP did very little science.

The biggest surprise was the optical discs. Although our tests gave inconsistent results, we do not feel that they are ready for use in this environment yet. Since we do not have a full explanation for the problems we saw, it is possible that a simple solution does exist.

Three deployments were performed. The first was in camp primarily to test the disc in a warm environment (in the water). This operated as a test bed and was accessible from the ARAMP hut in camp. About 10 Mbytes of data were recorded on the optical disk, but due to the location, the scientific use may be limited.

The second deployment was at a remote site. It was recovered after being fully installed because the string and the disc were not working.

The third deployment also recorded no data. Although the deployment and recovery were smooth, and all sensors were working at deployment and at recovery, the instrument did not record any data on optical disk while deployed. A possible explanation of this is a failure of the watchdog circuit.

The preparation and deployment process is now well established. Some improvements are suggested, but the basic design of the system is good. A more nearly operational system could now be advertised (when the disc problem is resolved).

Some experience was gained with helicopter deployment. It is felt that this is a viable alternative especially if more than a few ARAMP's are to be deployed. However some minor changes are recommended.

Due to other problems, very little use was made of the VHF telemetry. Contact was established with a buoy from a helicopter at 700 feet when the range was about 9.8 miles.

Problems and Repairs

1. Optical Disk

Temperature

Due to a misunderstanding, we did initial system tests at ambient temperature (-25 to -35 C). The discs did not perform correctly at these temperatures. Typical error messages were

DRIVE NOT READY, WAITING
FILE NOT FOUND
ERROR, DRIVE NOT READY, CHECK CARTRIDGE.

When files were written successfully, operation was very slow - of the order of minutes to write a small file (few Kbytes). The front panel light flashed at various rates whether or not the drive was active.

Power

When cold the alkaline lantern cells were barely adequate to drive the regulators (batteries measure 15 volts loaded giving 11.86 volts out). The power to the drive was changed so that the 12 volt regulator was driven by all 5 lantern cells and the 5 volt regulator was driven by the main gel cells. This also required a change to C18 on the ISI adapter board since the original was rated at 16 volts.

The 12 volts from the LM340-12 dropped to about 3 to 5 volts during spin-up. We determined that the 12 volt output on the NHance AC powered system on the NEC does not exhibit this characteristic however this does not appear to be a problem since successful operation was achieved even when this occurred.

The 5 volts from the 78M05 however is inadequate. The nominal typical load presented by the disk is 700 mA which is the same as the peak output for the 78M05. This was changed to a 7805 which meets the typical load requirement but still may not meet the initial surge (3.0 A).

Cartridge Eject

On several occasions in the ARAMP, the optical disk ejected when the unit was powered up. This seemed to be cured when the 5 volt regulator was changed to a 7805. Possibly the 78M05 let the 5 volts dip during the initial surge causing unpredictable results.

Lost files

The most persistent and as yet unexplained problem is deteriorating performance as more files are written on a given cartridge. Our guess is that the directory is corrupted on the disk which causes the system to lose files and to become very slow when writing new files and when mounting and accessing existing files.

The most interesting test in this connection is as follows. A test program was written which operated in a loop:

- power the drive,
- check the directory,
- copy a file to the disk,
- mount and list the label.txt file,
- turn off power
- wait one minute.

The program was run on the NEC and on LOPACS. On LOPACS it began to exhibit the lost files and slow operation after about 20 to 30 files had been written. On the NEC no problems were seen even after longer runs.

On one occasion, the program was run on the NEC until about 60 files had been written with no difficulty. The drive along with the NHance power supply and the same cartridge was moved to LOPACS where the program was run (adding files to the same cartridge). It ran correctly for about two cycles then it began to exhibit the lost files and slow operation problems.

The drive, cartridge, and power supply were then moved back to the NEC. The system still exhibited the lost files and slow operation problems. Our conclusion from this test is that LOPACS had caused a problem on the cartridge such as corrupting the directory.

This conclusion is supported by observations of disk operation. During a normal directory search (PDIR) the drive accesses the disk (brief flashes of the light) at several points when there are many files on the disk (reading different sections of the directory). When the problems occur, the light shows a lot of activity and the directory output is interrupted during this activity. Sometimes the directory listing ends even though many files have not been listed.

Front panel light/documentation

It was obvious from our tests that the front panel light is used to provide diagnostic information. When the drive was not active it would flash at different rates and duty cycles depending on what problems were occurring. Since we had no documentation, this was of little help.

Inconsistency

Many of the tests did not lead to definite conclusions because the results were inconsistent. There were several elements involved - drive, power, interface, cartridge, software, processor type - and we were unsure whether the long cold soak or other shipping problems may have caused damage to all systems.

Also we were unaware of what tests had been performed prior to shipment. Thus we could not tell whether our results were new information or an indication of a failure.

2. Electronics

FSK power (wire and fuse)

After the aborted deployment, the fuse on the FSK board was blown. No explanation was found for this although it was suggested that the reduced resistance of the wire in the cold may have lead to higher operating current.

The FSK board in the instrument was found to have no connection to the power control FET's gate. It was decided to short out the power FET to ensure that power to the FSK board was on. This modification was done to all instruments.

RS 232 levels

The INEXT and OUTEXT signals on the MEMORY I/O board were TTL/CMOS levels connected to RS 232 levels. This meant that the input clamp diode current exceeded the specified limit probably blowing the diode and eventually the chip (74HC04). Series resistors were added to limit the current after several failures were experienced.

Battery fire

On one occasion, the instrument with the battery connected was set on the bench in such a way that the chassis was resting on the power wires from the battery to the instrument. After some time and caused by movement of the bench (the floor was springy) the wires shorted and a fire ensued. It was quickly extinguished and little damage was caused but it could have been worse. Probably a fuse should be installed in the battery line.

Watchdog

Before leaving Woods Hole, it was found that using a 74HC4040 in the watchdog counter circuit lead to erratic times for the NORMAL watchdog - much less than the specified 34 minutes. Use of a CD4040B seemed to solve the problem. Late in the trip we looked at the circuit and found that with the 74HC4040, extra toggles occur on the wrong edge of the input clock line.

With the CD4040, extra toggles occasionally occur on the correct edge, but much less frequently. Probably filtering on the line would help - we took no action.

Another problem with the watchdog was failure to reset after 34 minutes. This was observed with the unit which was installed in camp since we had wire connection to it and could monitor the DEBUG output. No explanation for this problem was found. It is a serious problem however since as currently configured the system depends on the watchdog to restart the system after each 5-hour acquisition cycle.

A third problem is less well defined. It is suspected that occasionally the watchdog counter reset does not function leading to a system reset even when the watchdog is being repeatedly reset to prevent restarts. A special program - called TICK - was written to allow the instrument to be powered but not acquiring data (used to prevent operation during transportation to a deployment for example). It simply checks the clock and resets the watchdog timer every minute. On several occasions the system was left running TICK but was later found to be operating the acquisition program. This could have been caused by a false watchdog reset leading to execution of the standard start-up which leads to the acquisition program.

This could also have been the cause of the failure of the third deployment. Before the system reached the point of writing to disk (the only evidence we have of operation) the watchdog caused a reset.

Supply level 5.4v

The LOPACS power input is set to 5.4 volts to compensate for voltage drop across the power switch to the ISI adapter. Since 74HC circuits and memories are not specified for operation at 5.4 volts this seems risky. No problems were found that could be traced to this situation however.

Solder bridge

On one amplifier/filter board a solder bridge was found which shorted one of the bus lines to ground. This was located using the tests "ARAMP Deployment Preparation Procedures".

Extender board capability

Due to limited space at the connector end of the LOPACS chassis, the incoming cables are very short. This makes it almost impossible to extend these boards for troubleshooting.

V20 CPU

In an attempt to improve the system performance, the Harris 80C88 processor was replaced with a NEC V20. Several cold tests confirmed that these chips failed in the cold.

3. Cable/string

Connector sex

As suspected there was a connector match problem at the bottom of the bending strain relief. The cable from the buoy and the cable through the battery both had four-pin female connectors. We used an instrument harness (Y cable) to make the conversion but it was a mess - required extra connections and tie-offs in the string.

Bad TP

One TP failed to answer when connected. Due to other problems and lack of time, this one was not repaired.

Bad SACM

One SACM failed in the lab. In fact it prevented operation of the complete string. Again, the problem was not identified.

After a few days deployment, the SACM zincs showed considerable deterioration. No explanation was apparent.

TP strongback and mount

The strongback mount for the TP was judged poor. There was no good way to attach the TP to the strongback and its shape caused a problem during deployment and recovery.

We used fiber banding material to attach the TP but it required two people, hand assembly and was not very tight. It was easy to remove in the field however (quick cut with a knife)!

During deployment and recovery the strongback provided no convenient tie-off points. We simply looped the hand winch snap hook back on itself below the TP but this was not secure.

During recovery the strongback tended to catch on the bottom of the ice hole requiring some juggling to get it through. The use of a cage like the other instruments would help both the deployment and recovery problems.

Stop points

As prepared, the string had no stop points below the ARAMP and the instruments. These were judged essential for hand/winch deployment and were spliced on in each case.

Hydrophone mount

The hydrophone mount was not prepared before shipping and required some experimenting before the first deployment.

Connectors in cold

The Sea Con connectors are almost impossible to mate in the cold. We resorted to using a heat gun at close range with some success. The 1500 watt heat gun made the 1000 watt Honda work!

4. Rope Battery

Length

The last version of the rope battery seemed to be about 18 inches longer than expected. The battery transition cable wouldn't extend out both ends! On the aborted deployment, we tried letting the double clevis drop down in to the battery but there was also the sex changer so the end result was unacceptable. After a struggle recovering this system, we dispensed with battery deployments.

Support means

There was apparently no way to support the battery's weight when it was deployed. This would have left it supported on the bottom urethane cone which we judged would lead to its slipping down onto the current meter. A jury-rigged hanging method was arranged for the one deployment but it was labor intensive and was not suitable for a long deployment.

Performance

No provision had been made to monitor the battery's performance after deployment. Since one battery deployment was near camp, we were able to measure the system voltage on various occasions. These data have not been analyzed.

5. Deployment

Instrument weight

The fully assembled ARAMP registered about 170 Kg on the helo's dynamometer (over 200 with the rope battery). For two-man handling that is over 150 lb per man!

Delayed program start

As designed, the system begins acquisition whenever it is powered. When the system is being prepared for deployment, it is necessary to inhibit this process. This avoids running the radio transmitters with no antenna and prevents writing invalid data on the disc. As mentioned above program TICK provides this capability. The only danger would be if after the deployment external control is lost then the acquisition would never start.

Checkout procedure

As with any complex acquisition system, careful thought should be put into the procedures for deployment preparation. Document "ARAMP Preparation Procedures" is a start at this process. Likewise post deployment debriefing procedures may be necessary.

Reset button

An apparently trivial problem: the cable used to connect the ARAMP console to a PC for checkout provides a reset button. A simple button is too easy to get hit in the jumble of an overloaded helo workspace - use a locking switch to prevent accidents!

Electric hoist/chainfall

The electric hoist seemed like a good idea but failed at the crucial moment. During a difficult recovery, the load line slipped from the reel and got wrapped and jammed around the drive shaft. Ingenuity saved the day but the chain fall was used thereafter. For the record, the electric hoist did run even after a long cold soak.

Torpedo/Tarp

A torpedo heater was used during deployment and recovery to warm appropriate things. The tarp was not used because

- no problem was encountered with wind;
- rigging problems had not been solved;
- a clear workspace was desired.

The torpedo and the heat gun (mentioned above) were essential for the equipment and the people.

Gloves

Mechanical aids were used but inevitably hands got wet and the efficiency decreased. Probably divers gloves would help.

Helicopter Operations

All helicopter operations were successful. There was no problem slinging the ARAMP itself even with the rope battery attached (doubled back on the tube and lashed). Maximum speed with this helicopter slinging the ARAMP alone was about 65 knots. Higher speeds lead to erratic but not dangerous movements of the ARAMP.

One deployment used the helicopter to deploy the ARAMP, another deployment used it for recovery of the buoy and the complete string.

An attempt to sling the buoy and complete string was abandoned due to low ceiling. Otherwise such an operation would be no problem (with perhaps a heavier end weight).

For reference, some specifications for the helicopter used follow.

Aerospatiale AS 350B1 (Squirrel)

Cruising speed:	110 Kt
Cruising speed slinging ARAMP:	65 Kt
Cruising speed slinging ARAMP and rope battery:	35 Kt
Real lifting capacity (excluding pilot and fuel)	
- full fuel load:	600 Kg
- minimum fuel load:	1000 Kg
Allow per passenger:	80 Kg
Actual weight for ARAMP alone:	170 Kg
Actual weight for ARAMP and rope battery:	200 Kg

Painted tower

The painted meteorological tower is an aid in locating the ARAMP.

Radiator hose

The ARGOS PTT antenna required an external BNC co-ax connection. As a stop gap, we used a length of radiator hose with rubber stoppers and hose clamps to make this weather proof. This is not an appropriate solution in the cold weather because it is labor intensive and requires considerable heating of the components.

6. Software

DEBUG

The DEBUG routine included a call to KBHIT to allow for keyboard interruption of the system. This lead to mysterious hangups in operation probably caused by noise which looked like characters. The system then waited for another input from the keyboard leading to a permanent hangup during unattended operation.

ARGOS

The ARGOS routine was sending binary data to the telemetry section which was expecting ASCII data. This lead to hangups since the transmission routine was looking for '\0' to terminate the message.

Also the leading 'd' was missing which informed the telemetry section that the following data was to be sent as ARGOS data. Thus the whole message was ignored.

PUTAVG

There was an extra write statement causing one buffer to be written twice. Do the processing routines deal with this?

ARMAIN

When it was found that the V20 processor was unusable, the acquisition was changed to do two FFT's per minute and perform the averaging and log conversion after 12 sequences.

Log file

When the optical disk problems began, it became apparent that extra diagnostic information was needed. In the CPYFILES program, a record of optical disk error returns was written to a file (ODISK.LOG) on the C: drive. In this way, some record of what was attempted was available after a test.

SPAWN in TELECOM

The SPAWN call in TELECOM was hardwired to C:COMMAND. This worked during testing when apparently there was a copy of command on the C: drive but failed when running from EPROM when COMMAND was only on the A: drive.

Instrument Preparation Support

HYDTEST. To check that a hydrophone is functioning, it is necessary to power the cable/pre-amp, power the amplifier/filter cards, control the gains on the high, medium, and low channels, and run the A/D converter. This program was written for this purpose.

SENSGET. The original program - SENSTEST - used built-in routines to access the various sensors. It was found advantageous to use exactly the same routines in the test program as are use in the acquisition program. SENSGET is written in that way.

TICK. As described above, a program is needed which holds off the watchdog during certain periods of time. TICK serves this purpose.

Voltage readouts. No program exists or was written to read the various voltages in the system. This would be very valuable in instrument preparation.

VTERM XON/XOFF

Running acquisition tests while monitoring ARMAIN's DEBUG output is very convenient. If the monitoring is done on a PC using a terminal emulator such as VTERM, care must be taken that XON/XOFF protocol is disabled when the monitoring program is logging the DEBUG output. If it is not disabled, it issues XOFF while writing its local buffer to disk. If this buffer fills during the startup junk sent out by LOPACS, it may be seen by ARMAIN as an <ESC> character and thus stop operation.

File Download

The optical disk problems lead to an investigation of ways to down load data files from the C: drive to a PC in case it was necessary to use only the C: drive for data storage.

Kermit would not work even when the UART crystal was changed to 1.8432 and the BIOS was changed accordingly. It was apparently confused about using COM1 for operator communication as well as for file transfer. The XMODEM on the system is for file upload only. A down load capability would be a useful addition.

An alternative method is to use the VHF telemetry - see below.

CLEANIT

The VHF telemetry system has the capability to transfer data files from LOPACS over the data link to a remote computer. In the process, blocking is performed and various check characters are added. Program CLEANIT takes the raw received file and recreates the file as sent.

The program was tested in the lab but due to time limitations was not used.

7. NEC Power Mate

The NEC Power Mate 2 developed a mother-board fault. With any keyboard connected it will not boot. With no keyboard it boots and gives the error message but is fairly useless.

It was necessary to swap disk drives and various I/O boards with the comparable MIT system to continue ARAMP support.

8. Logistics

For first-time ice campers, logistics was the overwhelming consideration. It is impossible to perform too much pre-planning. The detailed packing lists should be kept for reference for another expedition.

Some simple lessons:
- 88 tape is useful but gets brittle
- filament tape just dies (!)
- duct tape is pretty good.

The mysteries of the camp AC power remain. It was the only explanation we could offer for the stream of nonsense characters that sometimes appeared on the line between the camp ARAMP and the monitoring PC. Various grounding and shielding schemes did nothing.

Some trouble was experienced with the FSK communication with the instruments when they were initially deployed in the test hole in the ARAMP hut. The problems were solved when a length of grounded copper wire was deployed the hole. Note however, that the problem also disappeared when the SACM was removed from the string. Without the copper wire we could see about 1.5 volts (pp) of 60 Hz. The wire reduced this to less than 1 volt. The connection of test gear also had an effect.

Suggested Improvements

Areas where improvements are needed are:
- special instrument handling gear is needed (the sled is great but not enough);
- complete long term system tests are needed
- more convenient test points are needed for various important signals.

Appendix 2. Summary of freezer tests

Summary of freezer tests

For both units, test programs were written which allowed the units to soak for a set period of time, then activate the disk and perform a file copy similar to that required during deployment. During the soak time, the internal temperatures and the voltages were recorded at regular intervals.

Typically the soak period used was 30 to 50 minutes for units in the laboratory freezer. For the tests at CRREL, this was extended to 2 to 5 hours to allow the heat generated during each active cycle to dissipate.

The tables which follow outline the tests performed with both units. Further explanations are offered in each case below the table.

Unit 2 Date	Configuration	Temp C	No. Cycles	Results
9 Feb	Swr v 4.03	-23	1	"drive not ready"
9-14 Feb		-6 -7	49	OK
		-11 -14	71	about half OK about half "not ready" "sector timeout"
		-20	3	"not ready"
16 Feb	Swr v 5.00	-5 -7	5	OK
		-9 -15	5	about half OK about half "not ready"
17-20 Feb	Purged N2	-8 -11	33	OK
		-12 -14	99	about half OK about half "not ready"
21-23 Feb	Fix for "not ready"	-12 -15	26	OK about half need CYCPWR apparent media error
		-18 -21	10	OK all need CYCPWR
		-22 -23	15	all need 3 or more
CYCPWR's				some still fail
2 Mar	ODSTART	-23 -24	4	"not ready" fail
		-16 -18	5	OK
27-30 Mar	CRREL	-2	25	OK

Unit 1

Date	Configuration	Temp C	No. Cycles	Results
7 Mar	3859/26211	-14 -15	20	"not ready" after starting OK - 6x
8 Mar		-13 -18	7	OK
		-20 -25	12	OK
9 Mar	3859/26213	-13 -15	15	"defect map" - 4x "not ready" - 1x
		-19 -24	7	"not ready" - 5x slow operation - 2x
11-12 Mar	5172/26213	-17	48	"not ready" - 5x
		-19 -23	21	slow operation - 1x
		-22 -25	22	"not ready" - 4x slow operation - 10x
27 30 Mar	CRREL	-2	27	"not ready" - 6x slow operation - 3x

Appendix 3. Summary of CRREL tests

ARAMP Tests at USA CRREL

K.Peal, 1 April 1990

Chronology

26 March
- packed gear at WHOI, drove to CRREL
- placed two ARAMP's into cold room already at -20C
- installed and checked out test gear

27 March
- installed two ARAMP's in water, wired to test gear
- ice thickness about 2"
- 1500Z to 2300Z, 1-hour disk test, both units

28 March
- 2300Z (27th) to 2000Z, 2-hour disk test, both units
- 2100Z, temperature set point changed to -10C
- 2000Z to 1300Z (29th), 5-hour ARMAIN acquisition

29 March
- test PTT, met pack, VHF radio during ARMAIN
- 1400Z to 1400Z (30th), 5-hour disk test, both units

30 March
- 1400Z, remove units from cold pit
- ice thickness about 6"
- packed up, drove to WHOI

Description of Tests

Disk Test

This is a disk exerciser program which reads engineering sensors at regular intervals while disk is off - cold soak. At predetermined time, turns disk on, copies files to disk, turns disk off. Length of cold soak is variable - used 1, 2 and 5 hour soaks. Engineering sensors include internal temperatures, voltages and meteorological package (to measure room temperature). Eight internal temperature sensors located as follows:

TP0 - top of internal frame
TP1 - 3 feet from top
TP2 - 6 feet from top
TP3 - 9 feet from top
TP4 - on disk support rail, inside hat
TP5 - on disk plate outside hat
TP6 - on disk drive, inside hat
TP7 - adjacent to disk, outside hat

Note that the overall length is 11 feet; sensors 4 through 7 are all in the last two feet near the disk drive. Below sensor 3 is an insulation plug which thermally insulates the disk drive from the frame above it. The "hat" is an insulating bag which fits over the disk drive to retain its heat (about 25 watts when on).

ARMAIN

This is the operational data acquisition program described elsewhere. Takes data from sensors, stores on disk and transmits over ARGOS PTT. During operation of this program, collected ARGOS uplink data and checked validity. Also operated VHF radio link to verify units both addressable. Meteorological package was connected during all tests.

Results

As expected the steady state temperature profile inside the instrument reflects the heat capacity of the water. The table below uses heavily extracted and rounded data. From these results it appears that the drives will not see temperatures much below a few degrees below 0C even assuming the "real" temperature profile (linear through the ice from -40 to -1.8).

Sensor #	"Real" profile	Unit 1		Unit 2	
		-20C	-10C	-20C	-10C
0	-40	-16	-8	-16	-8
1	-40	-15	-7.5	-15	-7.5
2	-25	-14	-6.5	-13.5	-6.8
3	-1.8	-10	-6	-6	-4.5
5	-1.8	-3.5	-2	-3	-2
drive	-1.8	-2	-1	-2	-1

Also evident from the above is a difference in the effectiveness of the insulation plug - unit 1 is better than unit 2. Unit 2 filled the space with chemical packing foam. Unit 1 filled the space with fiberglass batting.

A great deal of additional information can be drawn from the actual data collected. Of particular interest is the decay time of the heat pulse caused by each turn-on and write cycle of the disk drive. It takes more than two hours to dissipate.

No problems were experienced with the Mountain Optech disk drive as expected since the temperatures seen were not extreme.

Additional problems did appear with the ISI drive however. During the ARMAIN operation, it failed to complete the file copies all three times before the watchdog restarted the system. This was a new problem for which no explanation is as yet available. This drive also exhibited the "drive not ready" problem which appeared during the WHOI testing. An attempt to clear this problem by cycling power was unsuccessful. At this point it appears that these drives should not be used in this application.

Calibration of the temperature sensors was poor - a better calibration will be needed to make full use of the data.

Unit 2 exhibited a periodic data shift problem which affected all A/D channels. No explanation is as yet available. The data from unit 1 did not exhibit this problem.

Appendix 4. Deployment procedures

Predeployment Tests

These procedures should be performed in sequence prior to each deployment. They provide general confidence checks but do not include calibration or cold-temperature tests.

Initial Connection

Assemble electronics chassis complete with batteries. Batteries may be on charge during tests. Connect PC to console connector and install dummy loads on both PTT and VHF connectors.

A complete sensor string and meteorological tower should be accessible to confirm complete system operation.

Processor

Run suitable terminal emulation program on the PC (VTERM or PROCOMM) and power the ARAMP. When ARMAIN starts, hit <esc> in the first 30 seconds to regain console control. At this point you have 34 minutes to perform tests before the watchdog will restart the system. If a restart occurs, hit <esc> again as above. Note program TICK resets the watchdog every minute so may be used when no tests are being performed to prevent restarts.

Check the contents of the C drive in the ARAMP for the following programs. If any are missing, load them from the PC using XMODEM.

SENSGET	EXE	33024	1-01-80	4:55a
TICK	EXE	9984	1-01-80	10:46a
PWRUP3	EXE	5888	1-01-80	10:47a
SENDARG	EXE	28032	1-01-80	10:57a
ADCTEST	EXE	26880	1-01-80	10:50a
AMPTEST	EXE	12544	1-01-80	10:51a
HYDTEST	EXE	27136	1-01-80	10:52a
TESTFSK	EXE	7936	1-01-80	10:53a
FRAME	DAT	32	4-10-89	8:31p
TESTFSK	MAP	6784	4-10-89	9:28a
TESTCOMP	EXE	23040	4-10-89	10:39p

Power

The various sections of the instrument are powered separately from a central board controlled by the processor. It is easiest to check the individual power supplies while testing the various sections of the instrument.

Analog Section

Check analog section power. Run program AMPTEST and check that voltages at the Molex connector where the harness enters the analog section are:

pin 4	gnd
pin 3	-12v +-10%,
pin 2	+12v +-10%,
pin 1	+5v +-10%.

Table 1 shows the over-all connection and test points for this section.

Check A/D converter operation. Unplug the ribbon cable to A/D converter from the analog section. Connect the "signal injector" cable (BNC female to .025 pins adapter) between a DC power supply or calibrator and the A/D input pins on the A/D converter board directly. Run program ADCTEST selecting A/D channels 0 through 8 in sequence while connecting the DC voltage to the corresponding pins. Set DC voltage at several voltages between -5 and +5 volts for each channel and check that ADCTEST displays corresponding values.

ADCTEST channel	A/D pin no.
0	2
1	4
2	6
3	8
4	10
5	12
6	14
7	16
8	18

Check amplifiers operation. Remove co-ax inputs to the sensor input card. Add test point adapter on the 34-pin ribbon connector to the A/D board then add the ribbon cable from the analog section. Connect audio sine wave generator set for -50 dB via an adapter cable to the sensor inputs in turn as follows. Connect oscilloscope to the appropriate amplifier output at the A/D input. At each channel, set the oscillator as below and step the gain from 0 through 7 observing the sine wave on the oscilloscope.

Sine wave connection	AMPTEST channel	oscillator	scope to A/D pin
Hphone	0 (hyd low)	2 - 250 Hz	2
	4 (hyd medium)	250 - 1250 Hz	16
	5 (hyd high)	1 KHz - 10 KHz	18
Accel X	1	up to 250 Hz	4
Accel Y	2	up to 250 Hz	6
Accel Z	3	up to 250 Hz	8

Check VLF wiring from sensor input to A/D. The setup is similar to the above except that there is no amplifier involved and thus no program is running.

Sine wave connection	AMPTEST channel	oscillator	scope to A/D pin
VLF X	(none)	any	10
VLF Y	(none)	any	12
VLF Z	(none)	any	14

Internal Sensors

Check accelerometer power. Run program TESTCOMP and check the accelerometer power at J6 on the secondary power regulation and control board:

pin 2	gnd
pin 1	-12v +-10%
pin 3	+12v +-10%

Check accelerometer sensors. Connect sensor inputs to sensor input card. Leave test point adapter on A/D input cable as above. Stand the instrument on the floor (battery end down), power the unit and connect to console as before. Run program AMPTEST and change the gains for each sensor. Observe the inputs listed below with an oscilloscope.

Sensor	AMPTEST channel	scope on A/D pin	Action
Accel X	1	4	tap chassis horizontally
Accel Y	2	6	tap chassis horizontally
Accel Z	3	8	tap chassis vertically

For the following sensors, no system amplifier is used so the program is not needed.

Sensor	scope on A/D pin	Action
VLF X	10	move chassis slowly horizontally
VLF Y	12	move chassis slowly horizontally
VLF Z	14	move chassis slowly vertically

Check the accelerometer compass as follows. Run program TESTCOMP, turn the chassis to various known directions and wait for the reading to settle.

Recorder

Check recorder power. Remove recorder section cover, run program ON and check recorder voltages on the regulator box output:

black wire	gnd
red wire	+5v +-10%
white wire	+12v +-10%

Check recorder operation. A few seconds after running ON, the light on the recorder should go out and stay out except while drive is active writing or reading. To exercise the drive, do the following:

```
PDIR D:
MOUNT D:LABEL.TXT
TYPE D:LABEL.TXT
PCOPY A:ARMAIN.EXE D:
```

All commands should be completed in less than 10 seconds with no errors.

Telemetry

Before powering the telemetry section, ensure that the two antenna outputs have either an antenna or a dummy load connected. If a wattmeter is available, connect it to the PTT output.

Check telemetry section power. Run program PWRUP3 and check the voltages at J2 on the auxiliary power switches board:

pin 1	gnd
pin 2	+5v +-10%
pin 3	+12 +-10%

Check ARGOS PTT operation. Within a minute of running PWRUP3, the wattmeter should show a transmission and the TSUR should receive a transmission with an ID that matches that of the PTT in the telemetry section. Run program SENDARG, observe the character string it displays and confirm that the next reception on the TSUR from this PTT contains the same characters.

Check VHF data telemetry. Run program TELECOM. Note that this program watches the system time and terminates itself at 57 minutes before the hour. It thus may be necessary to change the system clock or wait a few minutes before running TELECOM to allow several minutes for this test. Set up the field telemetry unit and address this ARAMP: #Ann (where nn is the ARAMP serial number). The basic checkout is to enter passthrough from the field unit, open and transmit a file from the ARAMP to the field unit computer, then exit passthrough which terminates program TELECOM. Full instructions are found in the telemetry documentation.

Cable Sensors

Check cable power. With no cable connected, run program HYDTEST and check that cable power is correct at the Molex connector at the end plate:

pin 1	gnd
pin 4	+18v +-10%

Connect the complete string via an adapter cable to the cable Molex at the end plate. Run program HYDTEST again and check that the cable voltage is still correct.

Check hydrophone operation. While HYDTEST is running, remove the hydrophone cable from the end cap BNC and connect to an oscilloscope. It should show signal when the phone is tapped.

Reconnect the hydrophone cable to the end plate BNC and connect the scope to A/D input pins 2, 16 and 18 for the low, medium and high bands respectively. Run program HYDTEST. Select various bands and gains and check that the display varies as expected.

Check digital sensors. Run program SENSGET and observe the displayed output. Check that all sensors are present and that the values are reasonable.

Meteorological Sensors

Check meteorological section power. Run program SENSGET and check that the power at J6 of the auxiliary power switches board is as follows:

pin 1	gnd
pin 2	+12 +-10%

Check that all values displayed by SENSGET are reasonable.

Load Planning

For reference, table 2 shows suggested helicopter loads for deployment of a system.

Table 1

ARAMP Amplifier Connections and Test Points

Sensor	Conn	Amp #	Amp bd #	A/D chan	A/D pin #
Hydrophone	J1				
low		0	2	0	2
medium		4	1	7	16
high		5	1	8	18
Accel X	J2	1	2	1	4
Accel Y	J3	2	3	2	6
Accel Z	J4	3	3	3	8
VLF X	J5	(none)	(none)	4	10
VLF Y	J6	(none)	(none)	5	12
VLF Z	J7	(none)	(none)	6	14

Note amplifiers tuned as follows:

amp # 0	250 Hz LP
amp # 1	250 Hz LP
amp # 2	250 Hz LP
amp # 3	250 Hz LP
amp # 4	125 Hz - 1250 Hz
amp # 5	1 KHz - 10 KHz

Table 2

Helicopter Loads for Qudrapod Deployment

First Load
one passenger
qpod
ammo box (chainfall, handwinches, tripwires, cleats, lines)
topedo (fueled)
Diehard in cooler with cable to buoy
grease, gloves, wipes in a bucket
met tower, met pack, R.M.Young, antennas, arms
can of mogas
shovel
ice chisel
thin bore
beacon
marker mat
jiffy bit(s)

Second Load
2 passengers
ARAMP (with lifting collar, flotation collar, strain relief)
sensor string
Jiffy head
tools (socket set, large adjustable, short and long screwdrivers, 9/16 comb, 7/16 comb, large dikes, regular pliers, marlin, elec tape, tywraps, DC-4, 2 extension cords, heat gun)
hardware toolbox (3/8 hardware, pins, double clevis, bridle, dummy)
Honda generator
Toshiba with long grey cable, 9-25 cable, reset box cable
Telonics TSUR
two buckets

Appendix 5. Equipment Status

Equipment Status

The engineering changes developed during this work have been implemented on all five ARAMP units. In addition, the reconfiguration which places the disks in the lower portion of the unit has been performed on two of the ARAMP's. These two units are considered suitable for deployment in temperatures to -40C.

The units have been packed and stored in our warehouse until needed. If a deployment is planned, support will be required to reassemble and recommission the ARAMP's and to replace some components not returned after CEAREX.

A new assembly tower (quadrapod) has been produced to replace the unit lost during CEAREX. It had some minor improvements which have been found to be successful during testing.

No flotation collars were returned from CEAREX. If the systems are to be deployed in the same configuration, new collars will be needed.

The status of the the following components was recorded during system testing.

Temperature/pressure units:

S/N 8801, 8802, 8804, 8809, 8810	OK
S/N 8803, 8805, 8806, 8807, 8808, 8812	Will not address

Metocean PTT's:

ID # 4899	Lost during CEAREX
ID # 2529, 4888, 4890, 4892	OK
ID # 4886, 4894	No RF out
ID # 4897, 4898	unknown

Appendix 6. Outline of recommended documentation

Arctic Remote Autonomous Measurement Platform

Volume 1

System Overview and Manual Index

Table of Contents

1. Introduction

This document provides an introduction to the ARAMP and serves as a guide to the manuals which describe the system and its component parts.

The instrument is a multi-sensor platform designed to be deployed for extended periods in the Arctic while executing a predetermined measurement program. It contains a processor controlled data acquisition system, a high capacity data recorder and an RF telemetry section which has access to the main processor.

Sensors and transducers can be located on or above the ice, in the instrument housing itself and in the ocean beneath the ice. The electrical interface to the instrument can be a simple low- or high-level signal to be digitized or it can be a digital standard such as serial ASCII. Various forms of filtering and amplification can be performed.

The sampling strategy can be based on a predetermined time schedule or it can be adaptive. Considerable digital processing can be performed on sampled signals to effect data reduction or the results can be used to control future sampling.

The main processor is an IBM-PC clone running MS-DOS which considerably eases the development of acquisition and processing programs. It also simplifies field checkout since full communication exists with the processor allowing the operator to run test programs which verify operation of all parts of the system. Data are recorded in standard MS-DOS files on a large capacity optical disk.

The RF telemetry link provides for state-of-health checks on the system after it is deployed. It is also possible to retrieve previously recorded data files for examination. This capability can be used immediately after deployment to verify that the system is operational and it can also be used periodically during the deployment from overflying aircraft.

The system transmits limited quantities of data using the ARGOS satellite allowing further checks to be performed without going to the deployment site. The ARGOS system also provides instrument location.

2. Configuration

Although the system is a platform which can be used in many ways, these documents describe it configured as follows:

- meteorological tower above the instrument with bit serial communication to the main processor
- no external sensors on the ice
- three axis accelerometer and compass in the main instrument housing
- engineering measurements in the housing consisting of voltages and temperatures at several locations
- a multi-function cable connecting to a hydrophone and several digital instruments in the ocean.

In addition, one of two optical disk recorders is included. Although the IBM-PC architecture makes changing to other recorders possible, only two have been used to date.

3. Sensor Specifications

Details of the sensor specifications in this configuration are shown in a table.

4. Sampling Strategy

A summary of the acquisition and FFT calculation cycles in the present program.

5. System Operating Instructions

A description of the equipment needed and the checkout and deployment procedures is found in

Volume 2 - System Operating Instructions (arampop.man).

Details of the use of the RF telemetry system are given in

Volume 12 - Radio Telemetry (telem.man).

6. Processor and Acquisition Program

The processor is based on LOPACS (low power acquisition and control system). This consists of a passive IBM-style backplane with a set of boards including an IBM compatible processor board along with software support to use the system as a standard IBM-PC. The boards are described in

Volume 3 - LOPACS Hardware Manual (Prada).

The acquisition program, called ARMAIN, is contained in EPROM which in the LOPACS architecture simulates the IBM-PC's A: disk drive. In addition to ARMAIN, various support and diagnostic programs are stored in these EPROM's. This software is described in

Volume 4 - LOPACS Software Manual (Peal/Prada).

7. Measurements

Measurements are made as follows:
- using sensors and transducers connected to the analog signal conditioning and A/D converter
- using external acquisition systems with data transferred digitally to the system's processor.

An external meteorological acquisition package measures wind speed, wind direction, temperature, and humidity. The sensors are mounted on a tower above the ARAMP when deployed. Data are transferred through the upper end cap to the processor over a bit serial interface. This system is described in

Volume 5 - Meteorological Acquisition Package (met.man)

The accelerometer package contains three accelerometers with filtering electronics to give the responses shown in table 1 above. These signals are presented to the A/D for conversion. The package also contains the compass which is read in parallel by the processor. This package is described in

Volume 6 - Accelerometer and Compass Package (accel.man)

A group of engineering sensors is used to measure voltages and temperatures at various places in the instrument package. These are digitized by the A/D and recorded. These are described in

Volume 7 - Engineering Measurements (engsens.man)

In the ocean, the temperature and pressure at various points along the sea cable are measured with a self-contained instrument called a TP. It accesses the sensors regularly to provide averaged measurements when interrogated. The data are transferred to the processor on the cable using FSK SAIL. This instrument is described in

Volume 8 - Temperature Pressure Instrument
(tp.man).

Current flow past the cable is measured with an EG&G acoustic current meter. It too uses FSK SAIL to transfer data to the processor. It is described in the manufacturer's manual entitled

EG&G Ocean Products, Smart Acoustic Current Meter, Operation and Maintenance Manual, # 02901.

A hydrophone with a preamplifier is located at the end of the cable. Its output is divided into several frequency bands by filtering in the ARAMP's analog section. This is described in

Volume 9 - Analog Signal Conditioning
(analog.man).

8. Analog Signal Conditioning

The analog section provides a convenient package to do appropriate signal conditioning on sensor signals which are then connected to the A/D.

Signals from the accelerometers, the hydrophone, and the engineering voltage and temperature sensors are processed in this way. The processing and the hardware are described in

Volume 9 - Analog Signal Conditioning
(analog.man).

Volume 7 - Engineering Measurements
(engsens.man).

9. Sea Cable

The sea cable connected to the bottom of the ARAMP case carries the sensors and instruments to make the in-ocean measurements. The cable consists of a pair of conductors for the digital instruments and a co-axial cable for the hydrophone.

The pair of conductors are used to carry power to the instruments as well as for FSK signalling to communicate with them in a SAIL format. This is described in detail in

Volume 10 - Sea Cable
(cable.man).

10. Mass Store

The mass store is an optical write-once-read-many disk. Due to its sensitivity to cold, it is mounted near the bottom of the instrument (adjacent to the "warm" ocean water) in an insulated, heated section of the frame. The drive itself is used as received from the manufacturer.

The disk drive and its adapter are described in

Volume 11 - Optical Disk Drive
(disk.man).

11. RF Telemetry

The telemetry section provides the following types of data telemetry:

ARGOS satellite
VHF communication
VHF high speed data off-load.

These capabilities are provided by a processor based module which connects to the LOPACS section and to antennas on the external tower. The system is described in

Volume 12 - Radio Telemetry
(telem.man).

12. Chassis Wiring and Power

A wiring harness interconnects the sections and distributes power as needed.

Power is provided by a salt water battery charging an internal pack of sealed lead acid batteries. Provision is also made to connect auxiliary power to the instrument when needed.

Regulator and switching electronics provide power to the various modules and allow units to be turned on and off by LOPACS to control operation and conserve power.

These items are described in

Volume 13 - Chassis Wiring and Power Supplies
(power.man).

13. Frame and Structure

The internal structure consists of an aluminum frame which houses and supports the various electronics modules. This structure is supported inside a specially constructed aluminum cylinder for deployment. At the lower end, mechanical and electrical terminations connect the sea cable and the salt water battery. At the upper end, a removable cap provides access to the electronics and electrical terminations for external instruments and the operator's console. The meteorological tower mounts on the top cap. These items are described in

Volume 14 - Frame and Structure
(struct.man).

Appendix - Manuals, tables of contents

Volume 1 - System Overview and Manual Index
(this manual)

Volume 2 - System Operating Instructions
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Volume 3 - LOPACS Hardware Manual
(Prada).

Volume 4 - LOPACS Software Manual
(Peal/Prada).

Volume 5 - Meteorological Acquisition Package
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Volume 6 - Accelerometer and Compass Package
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Volume 7 - Engineering Measurements
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Volume 8 - Temperature Pressure Instrument
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Volume 9 - Analog Signal Conditioning
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Volume 10 - Sea Cable
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Volume 11 - Optical Disk Drive
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Volume 12 - Radio Telemetry
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Volume 13 - Chassis Wiring and Power Supplies
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4. Power Regulation
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Volume 14 - Frame and Structure
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    - insulation plug
    - rubber stoppers

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16. Abstract (Limit: 200 words)

A series of instrumented Arctic buoys has been developed which is designed to be deployed in pack ice to measure and record data from meteorological and ocean sensors as well as from an accelerometer package inside the buoy. Sophisticated in situ processing is performed reducing the data capacity required for the system's optical disk recorder.

Engineering development is described which aimed to identify and solve performance problems related to hardware and software deficiencies. One of the major hardware problems was that the optical disk was unreliable when exposed to the Arctic environment. Redesign was performed to insulate parts of the system from the cold. The test and evaluation sequence is described as well as the present status of all portions of the system.

Sample field data are presented including multiband acoustic spectra as well as time series environmental data.

17. Document Analysis a. Descriptors

Arctic instrumentation
optical disk recorders
ocean acoustic spectra

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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